PETER, A. MURPHY

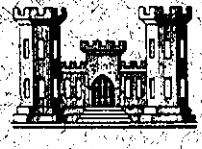
# HURRICANE SURVEY

# INTERIM REPORT

# WESTPORT

## CONNECTICUT

# APPENDICES



U.S. Army Engineer Division, New England
Corps of Engineers
Waltham, Mass.

31 March 1961

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(R 6-12-61)

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# GLOSSARY

HURRICANE SURGE: the mass of water causing an increase in elevation of the water surface above predicted astronomical tide at the time of a hurricane; it includes wind setup; sometimes the maximum increase in elevation is referred to as the surge.

HURRICANE TIDE: the rise and fall of the water surface during a hurricane, exclusive of wave action.

KNOT: a velocity equal to one nautical mile (6080.2 ft.) per hour (about 1.15 statute miles per hour).

OVERTOPPING: that portion of the wave runup which goes over the top of a protective structure.

PONDING: the storage of water behind a dike or wall from local runoff and/or overtopping by waves.

POOL BUILDUP: the increase in elevation of water surface behind a structure due to runoff and/or overtopping by waves.

RUNUP: the rush of water up the face of a structure on the breaking of a wave. The height of runup is measured from the stillwater level.

SIGNIFICANT WAVE: a statistical term denoting waves with the average height and period of the one-third highest waves of a given train.

SPRING TIDE: a tide that occurs at or near the time of new and full moon and which rises highest and falls lowest from the mean level.

STILLWATER LEVEL: the elevation of the water surface if all wave action were to cease.

STORM SURGE: same as "hurricane surge."

WAVE HEIGHT: the vertical distance between the crest and preceding trough.

WAVE TRAIN: a series of waves from the same direction.

WIND SETUP: the vertical rise in the stillwater level on the leeward side of a body of water caused by wind stresses on the surface of the water.

# APPENDIX A

## GEOLOGY

APPENDIX A

# APPENDIX A

## GEOLOGY

### PHYSIOGRAPHY

A-1. A series of three cuspate bars makes up the basic feature of the shoreline east of the Saugatuck River mouth. Cedar Point, at the mouth of the river, is an acute cuspate bar, one side uncompleted, while the apex is prolonged seaward in a slender spit connecting with a shoal or former island. Its eastern side is Compo Beach, the site of a recent sand nourishment project completed in the interest of beach erosion control. Sherwood and Frost Points, to the east of Cedar Point, are not as acute and display bouldery residues, offshore, of former islands or shoals. Saugatuck Shores, a peninsula projecting eastward, culminating in Seymour Point and Bluff Point, is the only shore feature in Westport to the west of the mouth of the Saugatuck River. Its position might suggest a strong eastward littoral drift situation, since it has caused the river to divert eastward into the Sound. Evidence to the contrary, however, see Plate A-1, indicates that it probably represents the remnants of a nearly obliterated Y-tombolo formerly connected to an island whose probable residue comprises Cockenoe Reef and Cockenoe Island. Cockenoe Island, almost a mile offshore, is the eastern extremity of a small island chain - Norwalk Islands - consisting of glacial debris and wave-built forms running parallel to the coast for about 3 miles and extending westward past the mouth of the Norwalk River. These islands, now greatly eroded, have supplied much of the drift materials supplying local beaches. Progressive erosion of the seaward flanks of the islands has changed their shapes and reduced their areas, see Plate A-1. Recession of the 2-fathom line off Saugatuck Shores and Cedar Point, as well as the Norwalk Islands, provides striking proof of the geological rapidity and extent of the erosion of the shorefront. The situation at Bluff and Seymour Points, at Saugatuck Shores, was so serious that their existence was totally threatened prior to re-establishment of the area by means of extensive protective works and the placement of huge amounts of dredged fill in 1925. The filled area now supports year-round and summer residences.

Plate A-1 also indicates that the largely filled tidal basin landward of Cedar Point is a natural salt marsh, thereby explaining mud deposits underlying the proposed protective works in the Grays Creek area. The marine sediments of this area merge inconspicuously with a low sand and gravel terrace of glacial origin. The dredging in 1930 of a yacht basin

north of Cedar Point provided fine-grained beach fill for the uncompleted tombolo arm west of the point. The fine character of the sand fill and a northwestward littoral drift condition, tending to complete the tombolo arm have resulted, however, in considerable flattening and loss of fill and have prompted interest in a large retaining jetty south of the entrance channel to the basin. The entire mass of Cedar Point, with its connecting beaches, would have been destroyed if a 460-foot jetty had not been constructed in 1837. Sixty feet of its outer end has settled or washed down but it still performs its intended function.

## FOUNDATION CONDITIONS

A-2. The proposed dike along the east side of Grays Creek will be constructed on marsh deposits. Probings indicate only a few feet of soft organic materials which it is believed will present no serious design problem in view of the low heights of the dike. The remaining portion of the alignment, traversing granular surficial materials, presents no foundation difficulty for a low dike.

## CONSTRUCTION MATERIALS

A-3. The securing of the small quantities of construction materials required in construction of the project is not seen to offer any problem, despite the presence of high-grade real estate developments throughout much of the area. A borrow pit containing gravelly sand and sandy gravel, with silt, lies about one-mile haul distance from the project site. Transit-mix concrete can be obtained from a source within five miles of the site.

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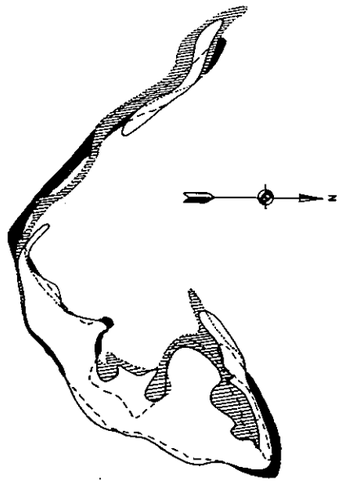
U.S. ARMY

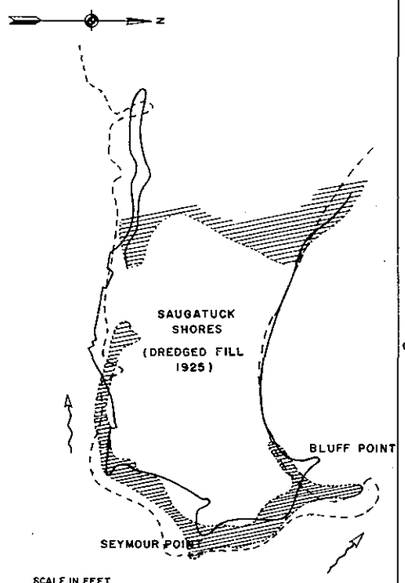


SCALE IN FEET
1000 500 0

LEGEND

1953 SHORELINE ———
1883-85 SHORELINE ·····
1835-38 SHORELINE – – – –

**SHORELINE CHANGES**
**COCKENOE ISLAND**




SCALE IN FEET
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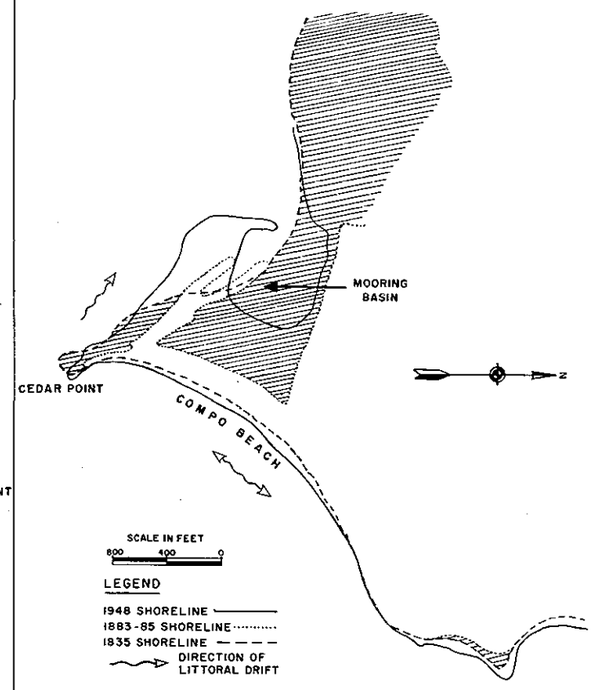
LEGEND

1959 ———
1883-85 -------
1835-38 – – – –
DIRECTION OF LITTORAL DRIFT

**SHORELINE CHANGES**
**SEYMOUR POINT & SAUGATUCK SHORES**

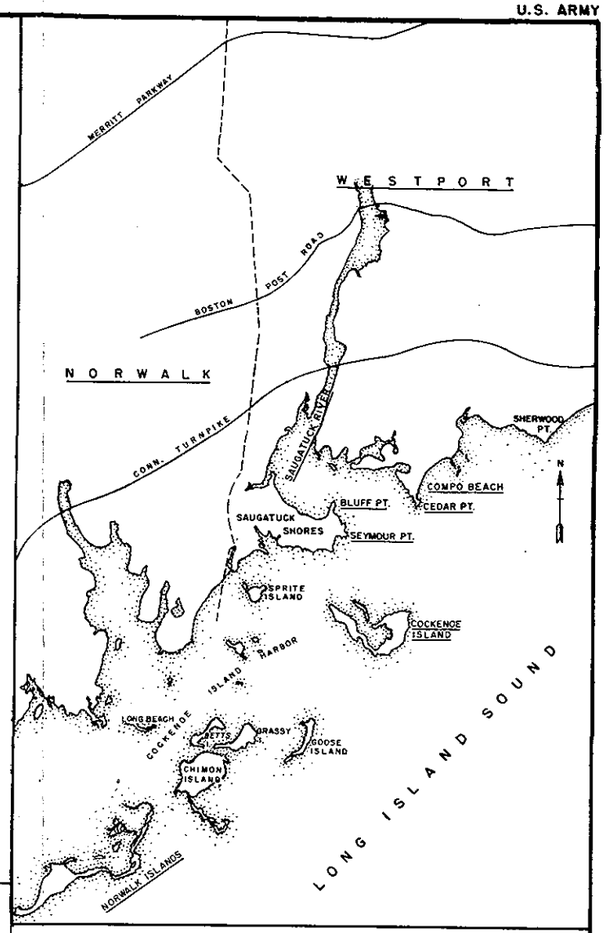



SCALE IN FEET
800 400 0

LEGEND

1948 SHORELINE ———
1883-85 SHORELINE ·····
1835 SHORELINE – – – –
DIRECTION OF LITTORAL DRIFT

**SHORELINE CHANGES**
**CEDAR POINT & COMPO BEACH**

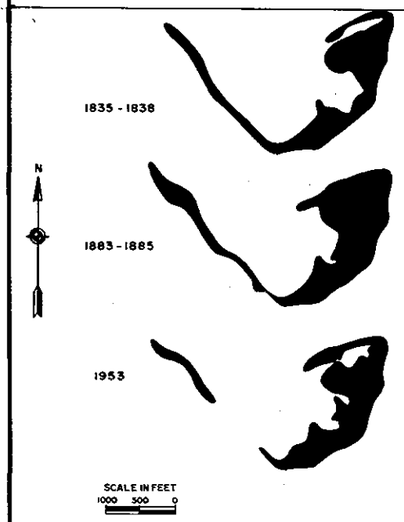



**VICINITY MAP**

SCALE IN MILES
0

**NOTES**

*Shoreline contours refer to mean high water.*
*Submarine contours refer to mean low water.*
*The drawings are based on information contained in House Document No. 174, 85th Congress, 1st Session, Areas 8 and 11, Saugatuck River to Byram River, Conn., Beach Erosion Control Study, May 6, 1957.*

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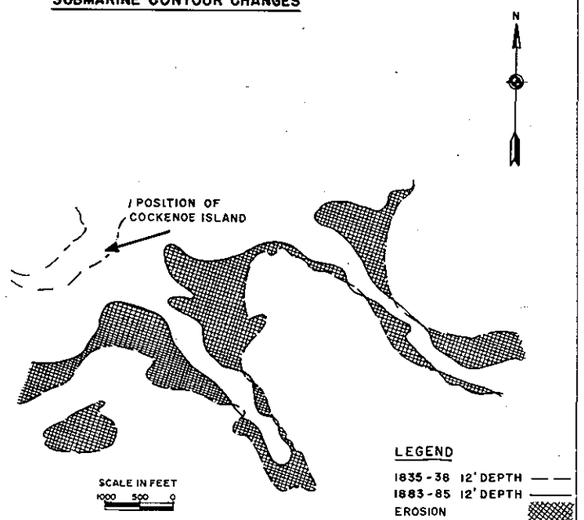
**SILHOUETTE CHANGES**
**COCKENOE ISLAND**

**SUBMARINE CONTOUR CHANGES**




SCALE IN FEET
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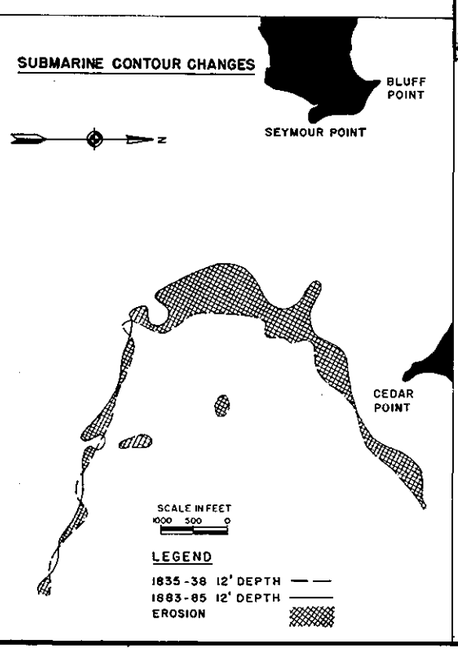
LEGEND

1835-38 12' DEPTH – –
1883-85 12' DEPTH ———
EROSION

**SUBMARINE CONTOUR CHANGES**




SCALE IN FEET
1000 500 0

LEGEND

1835-38 12' DEPTH – –
1883-85 12' DEPTH ———
EROSION

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

| DES. BY | DR. BY | CK. BY |
|---|---|---|
| CGH | | CGH |

SUBMITTED: Ted Hurley, HEAD, GEOLOGY SECTION
PROJECT ENGINEER: W.J. Hayden
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APPROVED: [illegible], CHIEF, ENGINEERING DIVISION
DATE: FEB 1961

HURRICANE SURVEY
WESTPORT, CONNECTICUT
COASTAL GEOLOGY

TO ACCOMPANY REPORT DATED 31 MARCH 1961

SCALE AS SHOWN
DRAWING NUMBER WC-2-1000
SHEET 1 OF 1

PLATE A-1

# APPENDIX B

## HYDROLOGY AND HYDRAULICS

APPENDIX B

# APPENDIX B

## HYDROLOGY AND HYDRAULICS

## INTRODUCTION

B-1. This appendix presents data to supplement the sections of the main report relating to hydrology and hydraulics. It includes a summary of temperature and precipitation data to amplify the section of the report on "Climatology," and data on hurricane wind velocities, rainfall values, and barometric pressures to augment report material on the characteristics of hurricanes. A determination of tidal-flood levels and design storm tide, and detailed analyses of wave height, runup, overtopping and ponding are also included.

## HYDROLOGY

### B-2. TEMPERATURE AND PRECIPITATION

Records of temperature and precipitation, covering a period of nearly 70 years, are available for the U.S. Weather Bureau Station at Norwalk, Connecticut, situated 3 miles west of Westport. These records are considered to be representative of conditions at Westport. Monthly means and extremes of temperature for 67 years of record at Norwalk, and mean, maximum, and minimum monthly precipitation data for 68 years of record, are summarized in Tables B-1 and B-2.

### B-3. DRAINAGE AREAS

The total drainage area behind the recommended dike protection in the Compo Beach area of Westport comprises 114 acres. This includes 61 acres of relatively flat residential property, with elevations ranging from 4 to 10 feet msl, lying south of Compo Road South. The remaining 53 acres, lying north of Compo Road South, is a hilly residential area with elevations ranging from about 7 to 100 feet msl. This latter area has a general slope of approximately one foot in 15. The total area behind the dikes, at the design flood level of 10.5 feet msl, equals 68 acres. This includes practically all of the 61 acres on the south side of Compo Road South and 7 acres on the north side. Of this total of 68 acres, 47 acres are tributary to the low-lying area immediately south of Compo Road South, 6 acres are tributary to the low area near the intersection of Quentin Avenue and Compo Beach Road, and 13 acres are tributary to the tidal pond on the north side of Compo Beach Road about 300 feet east of Roosevelt Road.

TABLE B-1

MONTHLY TEMPERATURES AND EXTREMES (1893-1959)

Norwalk, Connecticut

| | Degrees Fahrenheit | | | | Degrees Fahrenheit | | |
|---|---|---|---|---|---|---|---|
| Month | Mean | Maximum | Minimum | Month | Mean | Maximum | Minimum |
| Jan. | 27.7 | 70 | -22(1) | July | 72.2 | 102 | 42 |
| Feb. | 28.0 | 70 | -20 | Aug. | 70.2 | 104(2) | 34 |
| Mar. | 36.6 | 87 | -6 | Sep. | 63.6 | 102 | 28 |
| Apr. | 47.4 | 92 | 9 | Oct. | 52.9 | 90 | 16 |
| May | 58.5 | 96 | 24 | Nov. | 41.5 | 83 | -4 |
| June | 67.3 | 100 | 34 | Dec. | 30.4 | 71 | -16 |
| | | | | Annual | 49.7 | | |

(1) 5 Jan 1904 and 28 Jan 1935 (2) 26 Aug 1948

TABLE B-2

MONTHLY PRECIPITATION (1892-1959)

Norwalk, Connecticut

| | Inches | | | | Inches | | |
|---|---|---|---|---|---|---|---|
| Month | Mean | Maximum | Minimum | Month | Mean | Maximum | Minimum |
| Jan. | 3.56 | 7.35 | 0.54 | July | 4.02 | 11.81 | 0.65 |
| Feb. | 3.40 | 7.46 | .49 | Aug. | 4.84 | 15.80 | .37 |
| Mar. | 4.21 | 12.42 | .23 | Sep. | 3.87 | 15.64 | .23 |
| Apr. | 3.81 | 8.60 | .77 | Oct. | 3.47 | 17.23(2) | .31 |
| May | 4.02 | 10.78 | .07(1) | Nov. | 3.78 | 8.86 | .95 |
| June | 3.34 | 10.54 | .14 | Dec. | 3.78 | 8.56 | .85 |
| | | | | Annual | 46.10 | 62.95(3) | 33.67(4) |

(1) May 1903 (2) Oct 1955 (3) 1955 (4) 1935

B-4. STORM RAINFALL

The total rainfalls associated with recent hurricanes that have caused tidal flooding in Westport are: 11.16 inches in September 1938, 8.46 inches in September 1944, and 1.72 inches in August 1954. (Hurricane "Carol"). The maximum 6-hour rainfalls for these three storms at Westport are: 1.80 inches in 1938, 3.90 inches in 1944, and 1.13 inches in 1954. The maximum 6-hour rainfall for the 1944 hurricane is practically equivalent to a rainfall of 25-year frequency; the maximums in the 1938 and 1954 hurricanes, less than a one-year frequency. (See Weather Bureau Technical Paper No. 29, "Rainfall Intensity-Frequency Regime," Part 4-Northeastern United States). Owing to the time required, about 2.5 hours, for a hurricane surge to travel up Long Island Sound to Westport, from the eastern entrance to the Sound, the peak rainfalls at Westport in the recent hurricanes of record have been experienced prior to the occurrence of the peak stages of tidal flooding.

The storm of 14-17 October 1955, not a hurricane, caused five successive high tides at Westport which reached elevations of nearly 8.0 feet msl, approximately 4 feet above mean high water. The rainfall in this storm at Westport totalled 12.98 inches in 73 hours; 6.92 inches in 6 hours. This rainfall, which is the record rainfall at Westport, has a frequency well in excess of 100 years.

B-5. HURRICANE WINDS

The most reliable data on experienced hurricane wind velocities in New England begin with the September 1938 hurricane. The maximum velocity in New England during this storm was a recorded gust of 186 mph at the Blue Hills Observatory in Milton, Massachusetts, where a sustained 5-minute wind of 121 mph was also recorded. At other locations in southern New England, sustained 5-minute velocities ranging from 38 to 87 mph were experienced.

During the hurricane of 14 September 1944, a maximum gust of 109 mph was registered at Hartford, Connecticut. Sustained 5-minute velocities ranging from 33 to an estimated 85 mph were recorded at a number of locations between New York City and Block Island, Rhode Island, during this same hurricane.

In southern New England, during Hurricane Carol (31 August 1954) gusts of 125 and 135 mph were experienced at Blue Hill, Massachusetts, and Block Island, Rhode Island, respectively. Sustained 1-minute velocities ranging from 38 to 98 mph were registered.

Recorded wind velocities at a number of locations in southern New England and New York City, for the three great hurricanes of 1938, 1944, and 1954, are given in Table B-3.

The wind data in Table B-3 are for historical hurricanes that passed to the east of Westport and caused high surges to enter the east entrance of Long Island Sound. The winds at Westport in these three hurricanes were, in general, from the northern sector. This tended to decrease wave action in the Westport area. Hurricanes passing to the west of Westport by a distance of 50 miles or so would produce critical winds from the southern sector. These winds would cause greater wave action.

## B-6. HURRICANE BAROMETRIC PRESSURES

The center or "eye" of the 1938 hurricane entered Connecticut about 5 miles west of New Haven (20 miles northeast of Westport) at about 3:30 PM, EST, on 21 September and then proceeded northwesterly at a rate of 50 to 60 mph. The lowest pressure registered during the passage of this storm was 28.04 inches at Hartford, Connecticut.

In the hurricane of 14 September 1944, the "eye" of the storm passed inland between Charlestown and Point Judith on the south coast of Rhode Island (90 miles east of Westport) at about 10:20 PM., EST. It then continued in a northeasterly direction veering out to sea at Boston, Massachusetts. The minimum recorded barometric pressure in southern New England during this storm was 28.31 inches at Point Judith.

The center of Hurricane "Carol" (31 August 1954) crossed the south shore of Connecticut in the vicinity of New London (65 miles east of of Westport) at about 10:30 AM., EST, and then followed a general northwesterly path across New England. The minimum barometric pressures in New England upon the occasion of this hurricane were 28.20 inches at Storrs, Connecticut, (80 miles northeast of Westport) and 28.26 inches at New London.

The minimum pressures recorded at a number of New England locations and New York City during these three great hurricanes of the past 22 years are given in Table B-4.

TABLE B-3

WIND VELOCITIES

New England Hurricanes of 1938, 1944, and 1954

| Location | Velocity in Miles Per Hour: Sustained 5-Min. | Sustained 1-Min. | Maximum Gusts | Direction |
|---|---|---|---|---|
| **Hurricane of 21 September 1938** | | | | |
| New York, N.Y. | 70 | - | 80 | NW |
| New Haven, Conn. | 38 | - | 46 | NE |
| Hartford, Conn. | 46 | - | 59 | NE |
| Block Island, R.I. | 82 | - | 91 | SE |
| Providence, R.I. | 87 | 95 | 125* | SW |
| Milton, Mass. (Blue Hill Observatory) | 121 | - | 186 | S |
| **Hurricane of 14 September 1944** | | | | |
| New York, N.Y. | 81 | 99 | - | N |
| New Haven, Conn. | 33 | 38 | 65 | N &NE |
| Hartford, Conn. | 50 | 62 | 109** | N |
| Point Judith, R.I. | 85* | 90* | - | SSE |
| Block Island, R.I. | 82 | 88 | 100 | SE |
| Providence, R.I. | 43 | 49 | 90 | SE |
| Milton, Mass. (Blue Hill Observatory) | 67 | 77 | - | - |
| **Hurricane of 31 August 1954** | | | | |
| New York, N.Y. | - | - | 61 | NW |
| Bridgeport, Conn. | - | - | 60 | - |
| Hartford, Conn. | - | 56 | 64 | NE |
| New Haven, Conn. | - | 38 | 65 | N |
| Block Island, R.I. | - | 98 | 135 | SE |
| Providence, R.I. | - | 90 | 105 | ESE |
| Milton, Mass. (Blue Hill Observatory) | - | 93 | 125 | SE |

* Estimated
** Taken from indicator; clocked for 4 seconds

TABLE B-4

MINIMUM BAROMETRIC PRESSURES

New England Hurricanes of 1938, 1944, and 1954

| Location | Time (EST) | Barometer (inches) |
|---|---|---|
| **Hurricane of 21 September 1938** | | |
| New York, N.Y. | 2:45 PM | 28.72 |
| New Haven, Conn. | 3:30 PM | 28.11 |
| Hartford, Conn. | 4:17 PM | 28.04 |
| Block Island, R.I. | 3:05 PM | 28.66 |
| Providence, R.I. | 3:45 PM | 28.90 |
| Milton, Mass. (Blue Hill Observatory) | - | 29.01 |
| **Hurricane of 14 September 1944** | | |
| New York, N.Y. | 7:15 PM | 29.08 |
| New Haven, Conn. | 8:50 PM | 28.86 |
| Hartford, Conn. | 9:50 PM | 28.94 |
| Point Judith, R.I. | 10:20 PM | 28.31 |
| Block Island, R.I. | 10:09 PM | 28.34 |
| Providence, R.I. | 11:15 PM | 28.51 |
| Milton, Mass. (Blue Hill Observatory) | 12:11 AM(15 Sep.) | 28.62 |
| **Hurricane of 31 August 1954** | | |
| New York, N.Y. | - | 29.6 |
| Bridgeport, Conn. | - | 29.9 |
| New Haven, Conn. | 9:10 AM | 28.77 |
| Storrs, Conn. | 11:00 AM | 28.20 |
| New London, Conn. | 10:00 AM | 28.26 |
| Block Island, R.I. | 10:00 AM | 28.50 |
| Providence, R.I. | 11:12 AM | 28.79 |
| Milton, Mass. (Blue Hill Observatory) | - | 29.9 |

B-7. RUNOFF

Runoff studies for the drainage areas behind the recommended protective works in the Compo Beach area at Westport were predicated on the experienced hurricanes of 1938, 1944, and 1954; the storm of October 1955; and also on a 10-year, 6-hour rainfall applied coincident with a design tide at a 1938 flood level. Runoff hydrographs for 93 acres of drainage area, including the 53 hillside acres north of Compo Road South, were derived by the synthetic unit graph method in which the rainfall was applied to the respective one-half-hour unit hydrograph after deducting infiltration losses of 0.25 inch per hour. The estimated runoff from 93 acres, in four recent storms and one hypothetical condition, is given in Table B-6. The runoff from two lesser areas of 6 and 13 acres, south of Compo Road South, were estimated using an infiltration rate of 0.10 inch per hour.

## HYDRAULICS

B-8. HURRICANE OR STORM-TIDE FLOOD LEVELS

The heights of tidal flooding experienced at a number of locations in Westport and other Connecticut coastal areas during Hurricane "Carol" (1954) were obtained during the course of damage-survey work in the field. The elevations of these flood levels, referred to mean sea level, were then determined by a field level party. This information was supplemented by high water levels collected by this office after the September 1938 hurricane. Based on this information, profiles have been prepared of the 1938 and 1954 tidal-flood elevations between Willets Point, New York, at the western end of Long Island Sound, and Wareham, Massachusetts, at the eastern end of Buzzards Bay. A map and profile for the coastline between Willets Point, New York, and Fairfield, Connecticut, are included with this report. See Plates B-1 and B-2. For the Compo Beach area of Westport, at approximately Mile 30.0 on the profile, general levels of 10.5 feet msl in 1938 and 10.0 feet msl in 1954 are indicated. Tide curves for the 1938, 1944, and 1954 hurricanes are shown on Plate B-3.

In the preparation of tidal elevation-frequency data for Compo Beach, Westport, consideration was given to similar data which has been prepared for Stamford and Bridgeport Harbors, Connecticut. Compo Beach lies about 10.5 miles east of Stamford Harbor and 11.5 miles west of Bridgeport Harbor. The mean tide range at Stamford Harbor is 7.2 feet; at Compo Beach, 7.0 feet; and at Bridgeport Harbor, 6.8 feet. The tidal elevation-frequency curve for Compo Beach is based on (1) observed tidal-flood elevations for the 1938 and 1954 hurricanes and, (2) Stamford Harbor and Bridgeport Harbor tidal elevation-frequency data stage related to Compo Beach. Tidal elevation frequency data for Compo Beach,

Westport, is shown in Table B-5. The Compo Beach frequency curve, see Plate B-4, represents a composite curve based on 146-year period, 1815-1960, that influences the upper portion of the curve and a 23-year period, 1938-1960, for which there is a continuous tide gage record, that determines the lower portion of the curve.

TABLE B-5

## TIDAL ELEVATIONS VS FREQUENCY DATA

## HURRICANES AND SEVERE STORMS

### Compo Beach, Westport, Connecticut

| Hurricane or Storm | Estimated Maximum Tidal Elevation (2) (ft. msl) | Frequency Plotting Position(1) Percent Chance of Occurrence in any one Year. 1815-1960 | 1938-1960 |
|---|---|---|---|
| Hurricane, 21 Sept. 1938 | 10.5 (3) | 0.34 | 2.2 |
| Hurricane, 24 Aug. 1893 | 10.0 | 1.03 | |
| Hurricane, 31 Aug. 1954 | 10.0 (3) | 1.71 | 6.5 |
| Hurricane, 23 Sept. 1815 | 9.9 | 2.40 | |
| Storm, 25 Nov. 1950 | 9.2 | | 10.9 |
| Hurricane, 14 Sept. 1944 | 9.1 | | 15.2 |
| Storm, 7 Nov. 1953 | 9.0 | | 19.6 |
| Storm, 19 Feb. 1960 | 8.2 | | 23.9 |
| Storm, 15 Oct. 1955 | 7.9 | | 28.3 |
| Hurricane, 12 Sept. 1960 | 7.9 | | 32.6 |
| Storm, 30 Nov. 1944 | 7.7 | | 37.0 |
| Storm, 31 Oct. 1947 | 7.6 | | 41.3 |
| Storm, 20 Mar. 1958 | 7.4 | | 45.7 |
| Storm, 16 Feb. 1958 | 7.3 | | 50.0 |
| Storm, 14 Feb. 1960 | 7.3 | | 54.3 |
| Storm, 12 Mar. 1959 | 7.2 | | 58.7 |
| Storm, 27 Nov 1940 | 7.1 | | 63.0 |
| Storm, 29 Nov. 1945 | 7.1 | | 67.4 |
| Storm, 8 Dec. 1950 | 7.1 | | 71.7 |
| Storm, 29 Dec. 1959 | 7.0 | | 76.1 |
| Storm, 21 Apr. 1940 | 6.9 | | 80.4 |
| Storm, 16 Jan. 1945 | 6.9 | | 84.8 |
| Storm, 12 Nov. 1947 | 6.9 | | 89.1 |
| Storm, 23 Oct. 1953 | 6.9 | | 93.5 |
| Storm, 4 May 1954 | 6.9 | | 97.8 |

(1) Calculated Plotting Position:- $P = \frac{100\ (M-0.5)}{Y}$, where

P = percent chance of occurrence in any one year
M = number of the event
Y = number of years of record

(2) Based on tidal elevation data for Stamford and Bridgeport, stage related to Compo Beach, except as noted.

(3) Based on high water marks at Compo Beach

B-9. PONDING

All conduits under the dikes have been designed to accomodate the runoff from a 100-year rainfall. With the project in operation, ponding of runoff during periods when the conduit gates are open will not be greater than the ponding that occurs under present conditions. The proposed 48-inch conduit under the dike near the Minute Man monument is sufficiently large to permit future enlargement by the town of the existing 24-inch conduit in this area, under Compo Beach Road, to improve present ponding conditions in the low-lying area along the south side of Compo Road South.

An examination was made of the several ponding areas and their tributary drainage areas behind the dike protection in order to determine the damages from ponding of runoff to be anticipated during periods of gate closure. It was found that the most significant ponding area is the one drained by the proposed 48-inch culvert near the Minute Man monument which receives the runoff from 93 acres or over 80 percent of the total drainage area of 114 acres tributary to the protected area.

The volume of runoff that would pond behind the 48-inch culvert, with the gate closed, in the event of recurring 1938, 1944, and 1954 hurricanes; a recurring October 1955 storm; and a 10-year, 6-hour rainfall coincident with a recurring 1938 tidal-flood level, are summarized in Table B-6. The volume of fresh water that would accumulate in each event is predicated on the closure of all openings through the dike protection when the rising tide reaches a stage of 4.0 feet msl - the level where ponding begins in the low area behind the protection. This period of closure has been determined to approximate four to five hours. During the time when the tide is at and above a stage of 4.0 feet msl, when openings through the protection would be closed, the interior runoff under the several studied conditions would cause some ponding above an elevation of 4.0 feet msl, but, in general, would cause little damage. Damage from ponding begins at an elevation of approximately 5.0 feet msl. Maximum ponding would occur under conditions of a recurring October 1955 storm but the damage caused by this ponding, on an annual basis, would be small.

The volumes and peak levels of ponding that would be caused by runoff equivalent to that experienced in recent hurricanes and the October 1955 storm, and the runoff which would be experienced upon the occasion of a 10-year, 6 hour rainfall, in the area behind the 48-inch conduit, are shown in Table B-6. The ponding levels have been determined from the area-capacity curves shown on Plate B-5. These curves are based on U.S. Geological Survey maps supplemented by plane table surveys made in connection with the present investigation of the hurricane tidal-flood problem at Westport.



(R 6/12/61)

TABLE B-6

PONDING OF RUNOFF FROM 93 ACRES

HURRICANE PROTECTION FOR COMPO BEACH AREA

Westport, Connecticut

| STORM | Rainfall | | Runoff 6-Hour | | Ponding | |
|---|---|---|---|---|---|---|
| | Total (inches) | 6-Hour (inches) | (ac.ft.) | (inches) | Vol. (ac.ft.) | Elev. (ft. msl) |
| Hurricane, 1938 | 11.16 | 1.80 | 4.3 | 0.55 | 0.7 | 4.8 |
| Hurricane, 1944 | 8.46 | 3.90 | 19.8 | 2.56 | 16.7 | 6.6 |
| Hurricane, 1954 | 1.72 | 1.13 | 1.9 | 0.25 | 0.0 | 4.0 |
| Storm, Oct.1955 | 12.98 | 6.92 | 42.0 | 5.42 | 36.3(1) | 7.4(1) |
| 10-Year Rainfall, 1938 Flood Level | 3.45 | 3.45 | 19.0 | 2.45 | 13.3 | 6.4 |

(1) Overflow from adjoining areas adds approximately 2.2 acre-feet to volume and increases ponding elevation to 7.5 feet msl.



( R 6/12/61)

Some ponding would be experienced in the remaining 21 acres of drainage area on the south side of Compo Road South, particularly the 6 acres tributary to the low area in the vicinity of Quentin Avenue and Compo Beach Road and the 13 acres tributary to the tidal pond on the north side of Compo Beach Road. Damage from ponding begins at an elevation of approximately 7.0 feet msl in both areas. In the 6-acre area, the ponding levels would range from 4.3 feet msl in a recurring 1938 hurricane to 7.1 feet msl under recurring 1955 conditions. In the 13-acre area the ponding would range from a volume of about 0.2 acre-foot, at an elevation of 4.6 feet msl, under 1938 conditions, to a volume of about 6 acre-feet under conditions as experienced in 1955. In this latter case, of infrequent occurrence, the volume of ponding would cause flooding to an elevation of 7.8 feet msl and contribute about 2.2 acre-feet of ponding to the pool behind the 48-inch culvert.

B-10. STANDARD PROJECT HURRICANE STORM-TIDE DERIVATION

A memorandum dated 17 May 1957, to the Beach Erosion Board from the Department of Oceanography of the Agricultural and Mechanical College of Texas, in connection with research work being conducted by them under contract, contains the results of computations of hurricane surge potentials in Long Island Sound and forms the basis for the derivation of a Standard Project Hurricane surge at Westport. The evaluation of Standard Project storm surges for Long Island Sound was made by verification of analytical computations with information on observed high water levels in the sound during the 1938 hurricane. The wind and barometric pressure patterns utilized in the 1938 hurricane problem were taken from U.S. Weather Bureau Memorandum HUR 7-8 dated 1 June 1956. Computations were made for hurricanes advancing at speeds of 30 to 40 knots. From a surge viewpoint, the latter condition is most critical for the eastern and western portions of the sound, and the 30-knot hurricane, the most critical for the central portion. The Standard Project Hurricane corresponds to a transposition of the 1944 hurricane which was especially severe off Cape Hatteras, with wind field and pressures as specified in U.S. Weather Bureau Memoranda Nos. Hur 7-11 and 7-13, dated 15 June 1956 and 1 August 1956. This storm was considered to move northward along a path that would cause the region of maximum winds and highest surge to be directed into the eastern entrance of the sound, off Montauk Point, Long Island. In the Westport area, to allow for differences between observed and computed surges in the 1938 hurricane, the computed Standard Project Hurricane surge for the 40-knot storm was modified by the ratio of the observed to the computed 1938 surge. This gave a Standard Project Hurricane surge of 9.2 feet for the Compo Beach area of Westport, or 1.2 times the experienced surge of 7.5 feet in the 1938 hurricane.

To determine a Standard Project Hurricane stillwater level, the Standard Project Hurricane surge was added to a mean spring high water elevation of 4.4 feet msl. This gave a Standard Project Hurricane stillwater level of 13.6 feet msl, derived as follows:

| | |
|---|---|
| Surge, Standard Project Hurricane, | 9.2 |
| Mean spring high water | 4.4 feet |
| Standard Project Hurricane | 13.6 feet msl |

B-11. DESIGN TIDAL-FLOOD LEVEL

The design tidal-flood level at Westport has been established as equal to the record level of 10.5 feet msl experienced in September 1938. This is equivalent to a Standard Project Hurricane surge of 9.2 feet occurring coincident with a tide level at 1.3 feet msl (4.5 feet above mean low water). A tide level of 1.3 feet msl at Westport is equalled or exceeded about 40 percent of the time. The determination of a design level at 10.5 feet msl has been predicated on the economics of protection and the desires of local interest.

B-12. DESIGN WAVE HEIGHTS

A design wave height has been derived for the protection works at Compo Beach, Westport. It was determined for a fetch of 10.6 nautical miles and an hourly wind velocity of 47 knots (55 mph) from the west southwest coincident with the design tidal-flood level of 10.5 feet msl at Westport. This resulted in a design wave or significant wave height of 6 feet with a wave period of 5.2 seconds.

Wave heights also have been computed for a 95 mph wind from the south such as would be experienced in the event of a hurricane centered near New York City. Under such conditions, the tidal surge at Westport would not be appreciable. The tidal surges that enter Long Island Sound and cause flooding along the Connecticut coast originate from hurricanes moving along tracks passing near Montauk Point, L.I., east of Westport. Calculations of wave heights at Compo Beach, Westport, for a 95 mph wind have been based on a fetch of approximately 12 statute miles from the north shore of Long Island and a stillwater elevation of 8.0 feet msl (a high spring tide at 5.6 feet msl plus a wind setup of 2.4 feet). This results in a significant wave with a height of 13.5 feet and a period of 8.0 seconds. Since the toe of the protective structures along the shore are at an elevation of approximately 8.0 feet msl, the significant waves under these conditions would break before reaching the protection. A significant wave is the average of the highest one-third of the waves in a wave train. It will be exceeded by about 13 percent of all the waves in the train. Data on maximum wave heights are summarized in Table B-7.

## B-13. WAVE RUNUP AND OVERTOPPING

The amount of overtopping is important not only in the design of a safe structure but also from the standpoint of flooding that may be caused by the ponding of the overtopping water. Rates of overtopping were determined for a peak stillwater level of 10.5 feet msl for a one-half hour duration as estimated from the tide graph for the design hurricane shown on Plate B-3. The runup values were based on dikes with rubble slopes of rough angular stones.

The protection plan for Westport consists of dike protection for the residential area in the vicinity of Compo Beach. The top elevation of the dike varies as follows:

| | | |
|---|---|---|
| a. | Compo Hill to Agawam Ave.:- Elev. | 11.0 feet msl |
| b. | Agawam Ave. to Soundview Dr.:-Elev. | 11.5 feet msl |
| c. | Soundview Drive:- Elev. | 13.5 feet msl. |

Since the dike from Compo Hill to Agawam Ave. would experience a maximum wave with a height of one foot and a period of one second, the maximum runup along this length of dike would be 0.5-foot above design stillwater level of 10.5 feet msl. Therefore, with the top of dike at 11.0 feet msl no overtopping would be experienced. See Table B-7 for data on runup at this and other locations along the dike protection.

A maximum wave runup of 1.2 feet above the design stillwater level of 10.5 feet msl was computed for the dike running from Agawam Avenue to Soundview Drive. This was based on a 1.2-foot wave with a period of 2.7 seconds. With the top of dike at 11.5 feet msl, the maximum runup is only 0.2-foot above the top of the dike and would cause negligible overtopping.

The maximum wave runup on the dike along Soundview Drive varies from 1.4 to 3.2 feet above the design stillwater level of 10.5 feet msl. This is based on a design wave with a height of 6.0 feet and a period of 5 seconds. Computations indicate that insignificant overtopping would occur along this length of dike. Runup data were derived from curves, representing the results of laboratory studies, contained in Beach Erosion Board Technical Report No. 4.

TABLE B-7

WAVE HEIGHTS AND RUNUP

HURRICANE PROTECTION FOR COMPO BEACH AREA

Westport, Connecticut

| Location | Top Elev. of Dike (ft.msl) | Elev.of Ground at Toe (ft.msl) | Slope of Seaward Face (1) | Length of Dike (feet) | Maximum Wave Height at Toe (feet) | Maximum Runup Height(2) (feet) | Maximum Runup Elevation (ft.msl) |
|---|---|---|---|---|---|---|---|
| Compo Hill to Agawam Ave. | 11.0 | 4.0 | 1 on 2 | 2220 | 1.0 | 0.5 | 11.0 |
| Agawam Ave. to Soundview Dr. | 11.5 | 8.0(3) | 1 on 2 | 1220 | 1.2 | 1.2 | 11.7 |
| Soundview Drive | | | | | | | |
| Sta.37+00 to 39+30 | 13.5 | 10.0 | 1 on 1.5 | 210 | 0.4 | 1.4 | 11.9 |
| Sta.39+30 to 43+80 | 13.5 | 9.0 | 1 on 1.5 | 450 | 1.2 | 2.5 | 13.0 |
| Sta.43+80 to 47+40 | 13.5 | 8.0 | 1 on 1.5 | 360 | 2.0 | 3.2 | 13.7 |
| Sta.47+40 to 52+10 | 13.5 | 8.0 | 1 on 1.5 | 480 | 2.0 | 3.2 | 13.7 |

(1) Riprap
(2) Above design tidal flood level of 10.5 feet msl
(3) 9-foot contour

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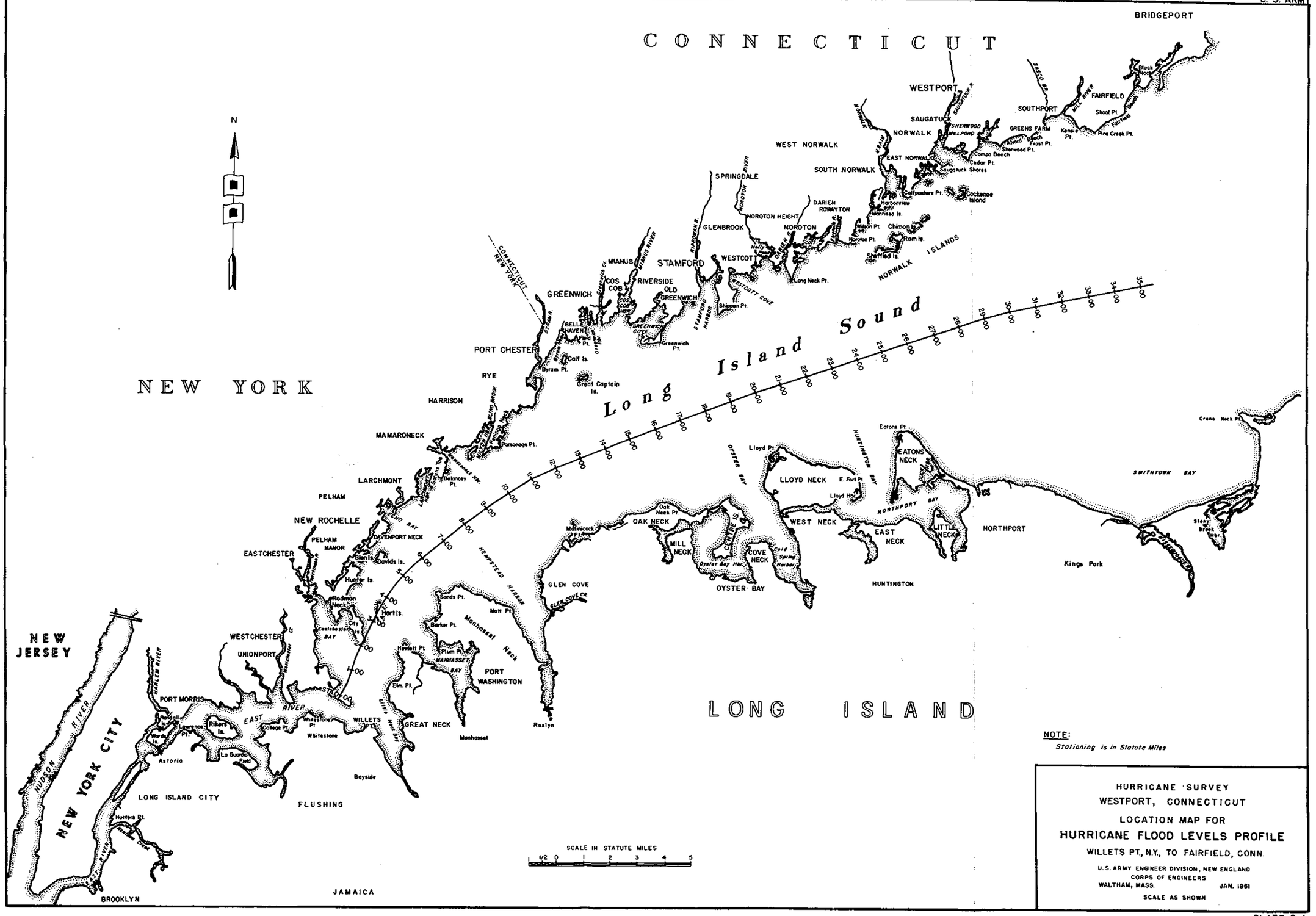
U. S. ARMY




NOTE:
*Stationing is in Statute Miles*

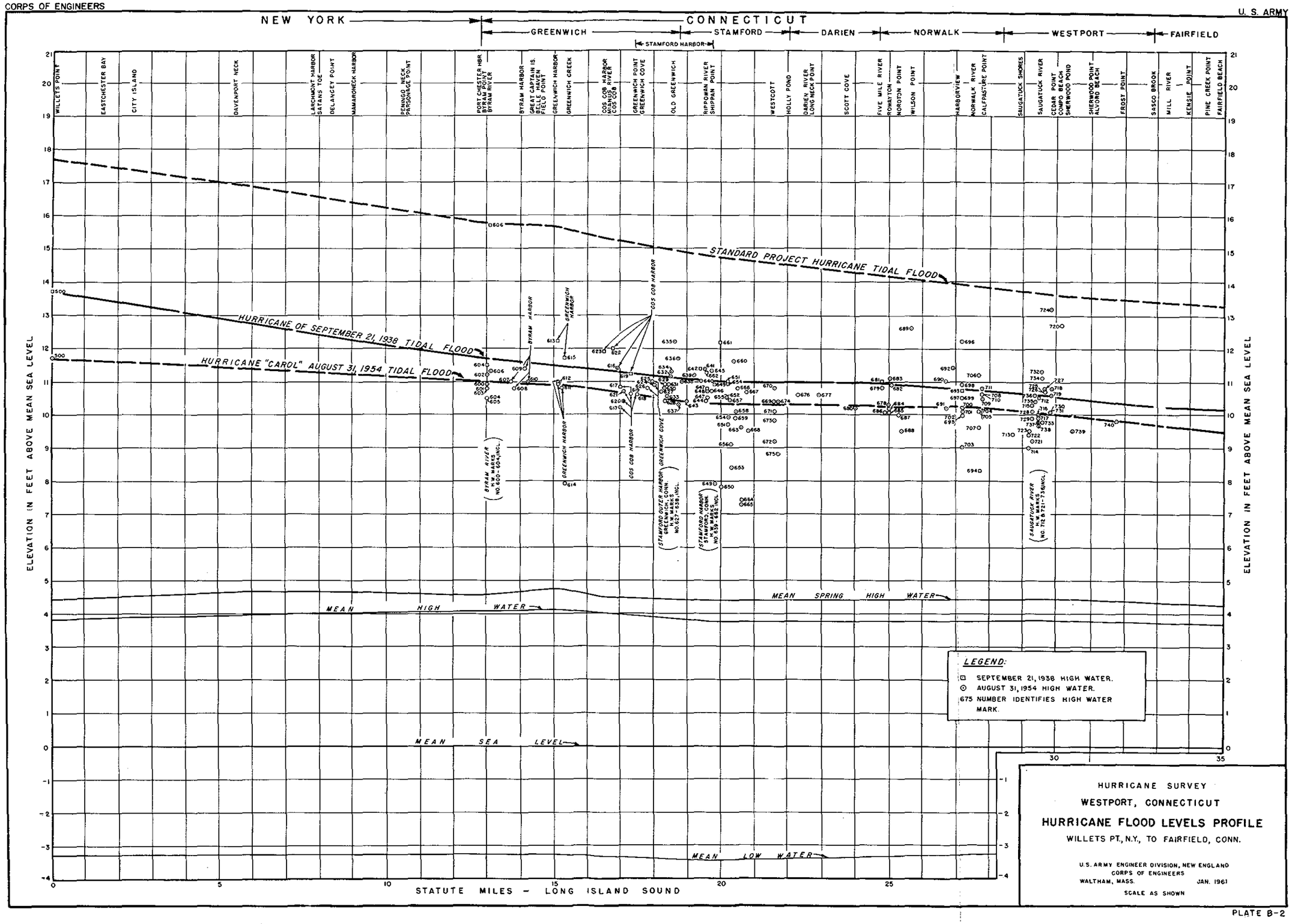
HURRICANE SURVEY
WESTPORT, CONNECTICUT
LOCATION MAP FOR
HURRICANE FLOOD LEVELS PROFILE
WILLETS PT., N.Y., TO FAIRFIELD, CONN.

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. JAN. 1961
SCALE AS SHOWN

PLATE B-1

CORPS OF ENGINEERS

U. S. ARMY




HURRICANE SURVEY

WESTPORT, CONNECTICUT

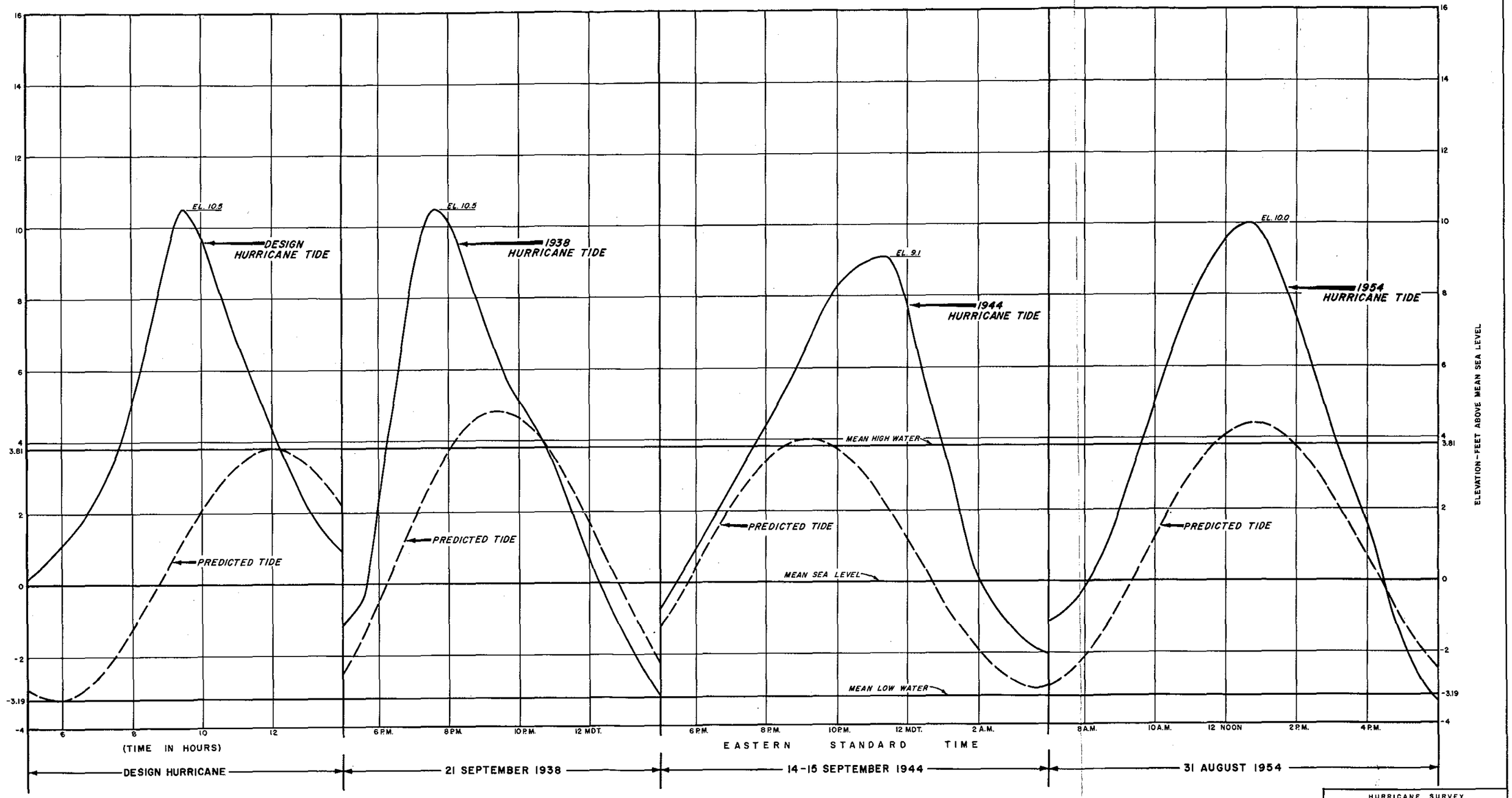
# HURRICANE FLOOD LEVELS PROFILE

WILLETS PT., N.Y., TO FAIRFIELD, CONN.

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. JAN. 1961

SCALE AS SHOWN

PLATE B-2




NOTE:

Design hurricane tide curve based on Texas A.&M. surge calculations for a standard project hurricane with a track most critical to Long Island Sound and with the peak of the surge coincident with a predicted tide of 1.3 feet, M.S.L.

NOTE:

1938-Hurricane tide curve based on high water marks at Westport and hurricane tide at Willets Point, N.Y., stage related to Westport.

NOTE:

September 1944-Hurricane tide curve based on high water marks in the vicinity of Westport and hurricane tide at New London, Conn., stage related to Westport.

NOTE:

August 1954-Hurricane tide curve based on high water marks at Westport and hurricane tide at Bridgeport, Conn., stage related to Westport.

HURRICANE SURVEY

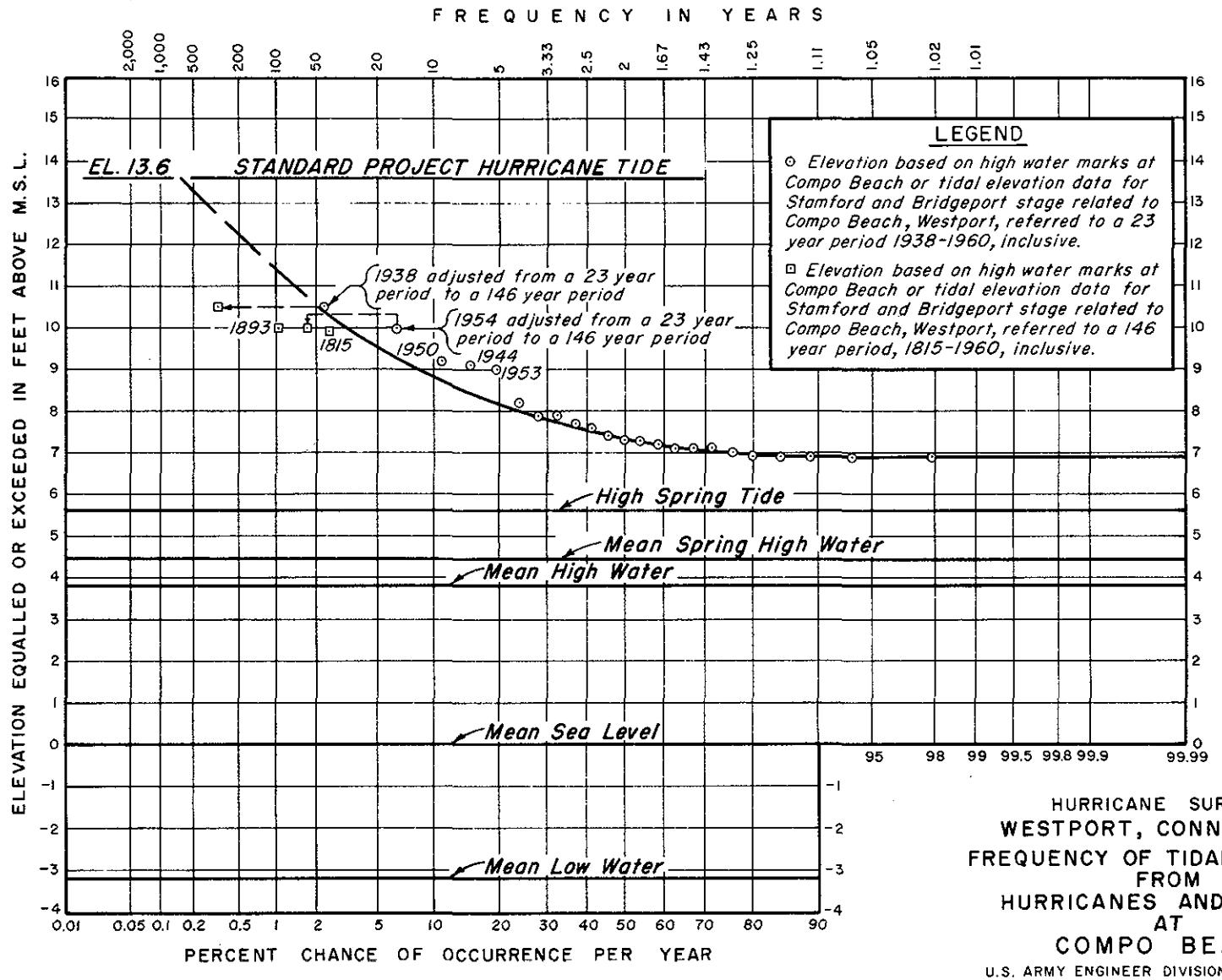
# WESTPORT, CONNECTICUT

## TIDE CURVES

## DESIGN, 1938, 1944, & 1954 HURRICANES

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. JUNE, 1960

PLATE B-3



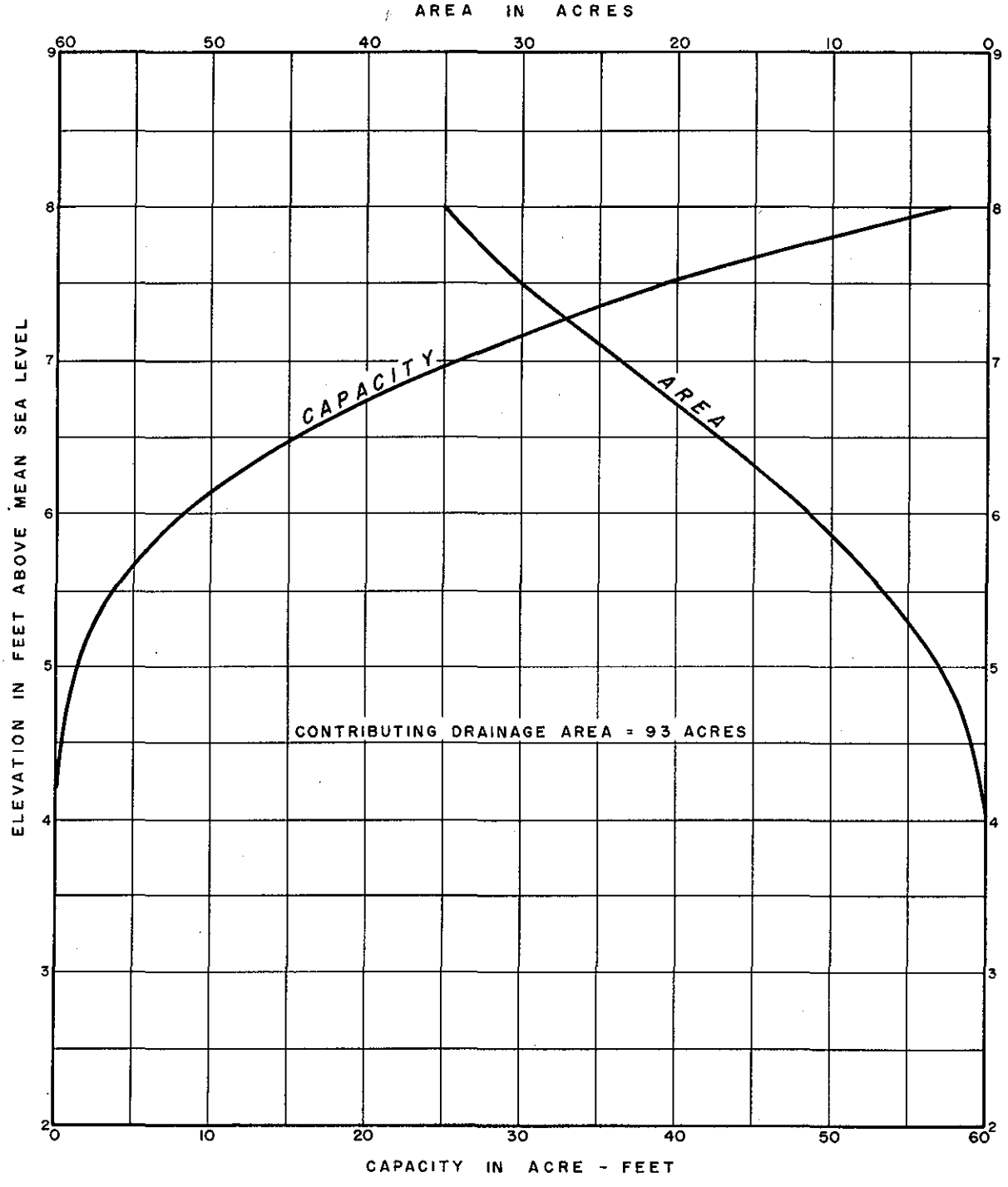

HURRICANE SURVEY

# WESTPORT, CONNECTICUT

## FREQUENCY OF TIDAL FLOODING FROM HURRICANES AND STORMS AT COMPO BEACH

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. FEB. 1961

PLATE B-4




HURRICANE SURVEY

**WESTPORT, CONNECTICUT**

AREA AND CAPACITY CURVES

PROTECTION FOR COMPO BEACH AREA

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. FEB. 1961

PLATE B-5

# APPENDIX C

# HISTORY OF HURRICANES

APPENDIX C

# HISTORY OF HURRICANES AND OTHER STORM OCCURRENCES

## C-1. GENERAL

In order to determine the possibility of future hurricane occurrences, a review has been made of historical data on past hurricanes that have struck or threatened the coast of Connecticut. Since the eastern entrance of Long Island Sound lies in the path of hurricanes moving into New England from the south, the Connecticut coastline, on the north shore of the sound, has frequently been subject to tidal flooding from hurricane surges moving west up the sound. The records indicate that the coast of Connecticut, including Westport, has experienced or has been threatened by hurricane tidal flooding upon 64 occasions since 1770. The greater number of these hurricanes, owing to the locations of their paths, did not cause tidal flooding along the Connecticut shore. However, they did present a potential threat of such flooding. Of the 9 hurricanes that have caused severe tidal flooding, the 5 greatest, as far as can be determined from existing records, are listed below in their estimated order of magnitude.

21 September 1938
24 August 1893
31 August 1954
15 September 1815
14 September 1944

In recent years, the hurricanes that caused tidal flooding along the coasts of Rhode Island and southern Massachusetts also caused flooding along the Connecticut coast. Prior to 19 October 1770, five hurricanes are known to have affected the coastal areas of Massachusetts and Rhode Island. The two earliest of these storms, namely those of 15 August 1635 and 3 August 1638, caused extensive tidal flooding, probably the greatest ever experienced in New England during the past 200 to 300 years. Since there was very little development along the Connecticut shore until after 1638, there are no available records to indicate that these storms affected Long Island Sound. It is reasonable to assume, however, that they did cause inundation of the coastal lowlands of Connecticut.

Since the extent of flood damages is relative to the degree of development in the areas flooded, the early great hurricanes were not nearly as damaging as those of the present century. As a matter of fact, the two earliest hurricanes of record in New England, which according to history must have been very severe,

occurred prior to the settlement of Westport and other cities and towns along the Connecticut coast. The recurrence of these two hurricanes under present conditions would cause extensive damages, possibly in excess of the damages sustained in September 1938.

## C-2. SUMMARY OF HURRICANE AND STORM OCCURRENCES

A summary has been prepared, see Table C-1, which lists all hurricanes known to have directly affected the coast of Connecticut, and also, all hurricanes known to have threatened the area. In the latter case, a slight change in meteorological conditions could have caused any of these hurricanes to follow a course more critical to Long Island Sound, thereby subjecting the Connecticut coastal area to tidal flooding. The following classifications indicate the effect of the recorded hurricane occurrences on the Connecticut coast:

Type "A": Hurricanes causing severe tidal flooding.
Type "B": Hurricanes causing damage from wind and rainfall (usually accompanied by high seas and moderate tidal flooding).
Type "C": Hurricanes threatening the area.

Of the 64 hurricanes of record, listed in Table C-1, that have either caused or threatened damage along the Connecticut coast since 1770, 9 are of type "A," 24 of type "B" and the remaining 31 of type "C." Forty-three of the listed hurricane experiences (3 type "A," 14 type "B," and 26 type "C,") have occurred during the period from 1901 to 1960. The fact that there is a record of 43 hurricanes in this 60-year period, as compared with 21 in the 131-year period from 1770 to 1900, is not considered indicative of a greater trend in hurricane activity in recent years but to a lack of records and information on storms prior to 1900.

TABLE C-1

HISTORICAL HURRICANES

Connecticut Coast

| Date of Hurricane | Category (1) | Source of Data | Remarks |
|---|---|---|---|
| 1635, Aug.15 | A | (2)(3) | Great tidal surge along coast of R.I. Effect on Conn. coast not known. |
| 1638, Aug. 3 | A | (3) | Historical account indicates greatest tidal flooding ever experienced along Mass. and R.I. coast. Effect on Conn. coast not known. |
| 1723, Oct. 30 | A | (3) | Very high tide in R.I.; considerable damage. Effect on Conn. coast not known. |
| 1757, June 30 | C | (2) | Atlantic Coast hurricane, Florida to Boston, Mass. Effect on Conn. coast not known. |
| 1761, Oct. 24 | A | (3) | Very high tides in Narragansett Bay, R.I. Damage from wind and water. |
| 1770, Oct. 19-20 | A | (3) | A violent storm; immense loss of life and property along the coast. Report of boat damage at New London, Conn. |
| 1773, Aug. 19 | C | (2)(3) | Passed near Boston, Mass. "Abundant showers" in Conn. |
| 1787, Sept. 19 | B | (3) | Reports of damage at Stanford and Norwalk, Conn. |
| 1788, Aug. 19 | B | (2)(3) | Affected westerm New England; much damage in Conn. and Mass. |

(Footnotes are at end of table.)

TABLE C-1 (Cont'd)

| Date of Hurricane | Category (1) | Source of Data | Remarks |
|---|---|---|---|
| 1804, Sept. 8-9 | C | (2) | Severe storm passed over Cape Cod, traveling northeast. No account of damage in Conn. |
| 1804, Oct. 9-10 | B | (2)(3) | Reports of minor wind and rain damage. |
| 1815, Sept. 22-23 | A | (2)(3) | Very high tide; considerable damage along Conn. coast from tidal flooding. |
| 1821, Sept. 3 | A | (2)(3) | Wind damage to boats and homes. Tidal flood damage at New London, Conn. |
| 1829, July 24 | C | (2)(3) | Reported to have been felt in Boston, Mass. No accounts of damage in Conn. |
| 1841, Oct. 2-4 | B | (2)(3) | Violent winds and heavy rain; reports of wind damage at Hartford, Conn. |
| 1854, Sept. 10-11 | C | (2)(3) | Severe in southern states; passed over New England, near Boston. Heavy rain and high winds at New Haven, Conn. |
| 1866, Oct. 29-30 | B | (2)(3) | Reports of wind damage. |
| 1869, Sept. 8 | A | (2)(3) | Tidal-flooding at Mystic, Conn. |
| 1877, Oct. 4-5 | C | (2)(3) | Path was south of Long Island and Nantucket. No accounts of damage in Conn. |
| 1878, Oct. 22-23 | A | (2)(3) | Reports of wind damage at Bridgeport; very high tide at Greenwich, Conn. |
| 1878, Dec. 10 | B | (3) | Reports of wind, rain, and minor tidal-flooding along the coast. |

TABLE C-1 (Cont'd)

| Date of Hurricane | Category (1) | Source of Data | Remarks |
|---|---|---|---|
| 1879, Aug. 18 | B | (2)(3) | Passed over Cape Cod. Damage to crops from wind and rain at Stamford, Conn. |
| 1889, Sept. 10 | B | (2)(3) | Streets in Stamford flooded by heavy rain. Very high tide at Greenwich, Conn. |
| 1893, Aug. 23-24 | A | (2)(3) | Wind, rain, and high tide caused damage. |
| 1893, Aug. 29 | B | (2)(3) | Storm passed west of New York City, crossed central Maine, moving northeast. Reports of high tides and heavy surf along Conn. coast. |
| 1896, Sept. 9-10 | B | (2)(3) | Torrential rain and hurricane winds. Reports of tidal flooding along R.I. coast. |
| 1901, Sept. 19 | C | (2)(4) | Passed south and east of Cape Cod. |
| 1902, June 16-17 | C | (2)(3)(4) | Path crossed Buzzards Bay and Cape Cod, moving northeast. Strong winds over L.I. Sound. |
| 1902, June 29-30 | C | (2) | Center passed over Conn. and southern R.I., traveling southeast; no account of damage. |
| 1902, Oct. 12 | C | (2)(3)(4) | Path south of Long Island and Nantucket, moving east. Heavy rain and high wind at New Haven, Conn. |
| 1903, Sept. 16 | B | (2)(3)(4) | Storm crossed northeastern Pa., moving northwest. High winds and high water along Conn. coast. |

TABLE C-1 (Cont'd)

| Date of Hurricane | Category (1) | Source of Data | Remarks |
|---|---|---|---|
| 1904, Sept. 15 | B | (2)(3) | Center passed over northeastern Conn., moving northeast. Reports of wind damage. |
| 1904, Nov. 13 | B | (2)(4) | Passed south of Nantucket, moving northeast. Reports of wind damage. |
| 1911, Sept. 1 | C | (2) | Passed south of Cape Cod. No accounts of damage in Conn. |
| 1912, Sept. 16 | C | (2) | Followed easterly path across southern New England. |
| 1916, July 21 | C | (2)(4) | Passed off east end of Cape Cod, heading northeast. |
| 1920, Sept. 30-Oct. 1 | B | (2)(3)(4) | Storm passed just west of New York, heading north. Reports of damage from high tides along Conn. coast. |
| 1923, Oct. 19 | C | (2)(4) | Passed near Boston, moving northwest. Storm of slight energy. |
| 1924, Aug. 26 | B | (2)(3) | Crossed tip of Cape Cod, moving northeast. Some damage from strong winds. |
| 1929, Oct. 2 | B | (2)(4) | Moved northeast, passing over eastern New York and northwestern Vermont. High tides caused damage along Conn. coast. |

TABLE C-1 (Cont'd)

| Date of Hurricane | Category | Source of Data | Remarks |
|---|---|---|---|
| 1933, Aug.23-24 | B | (2)(3) (4) | Driving rain and high tides along Conn. coast. |
| 1933, Sept.16-17 | C | (2)(3) | Passed south of Cape Cod, moving northeast. No reports of damage in Conn. |
| 1934, June 19 | C | (2) | Traveled overland from Louisiana; crossed Long Island and Cape Cod, moving northeast. |
| 1934, Sept. 9 | B | (2)(4) | Crossed Long Island and central Conn. moving north. Wind damage along Conn. coast. |
| 1936, Sept. 19 | B | (2)(3) (4) | Passed south of Nantucket, heading northeast. Wind damage along Conn. coast. |
| 1938, Sept. 21 | A | (2)(3) (4) | Most damaging storm to strike southern New England. 7.5-foot surge at Westport caused tidal flooding to 10.5 feet msl. |
| 1940, Sept. 2 | C | (2)(4) | Passed south of Nantucket, heading northeast. No accounts of damage in Conn. |
| 1940, Sept. 16 | C | (2)(4) | Followed northeasterly path east of Cape Cod. No accounts of damage. |
| 1943, Oct. 17 | C | (2)(4) | Passed east of Cape Cod, moving due north. No accounts of damage. |
| 1944, Aug. 3 | C | (2)(4) | Moved northeasterly along path south of Long Island and Nantucket. No accounts of damage. |
| 1944, Sept.14-15 | A | (2)(3) (4) | Center passed over Providence, R.I. and south of Boston, Mass. Surge of 6.9 feet at Westport caused tidal flooding to 9.1 feet msl. |

TABLE C-1 (Cont'd)

| Date of Hurricane | Category (1) | Source of Data | Remarks |
|---|---|---|---|
| 1944, Oct. 21 | C | (2)(4) | Path crossed over Nantucket and tip of Cape Cod. No accounts of damage. |
| 1945, June 26 | C | (2)(3)(4) | Followed northeasterly path from Florida to Nova Scotia, passing south of Nantucket. |
| 1945, Sept.19 | C | (2)(4) | Overland from Florida; passed just west of New York, moving northeast. |
| 1949, Aug.29 | C | (2)(3)(4) | Traveled overland from northern Florida, crossed center of Maine. High winds at Greenwich,Conn. |
| 1950, Aug. 26 | C | (2)(3)(4) | Passed south of Nantucket, heading generally northeast. Heavy rain at Greenwich, Conn. |
| 1950, Sept.11 | C | (2)(3)(4) | Passed south and east of Nantucket, then headed east. No reports of damage in Conn. |
| 1952, Sept. 1 ("Able") | C | (2)(3)(4) | Followed northeasterly track, approximately over New York. Heavy rain and high wind at Greenwich, Conn. |
| 1953, Aug. 15 ("Barbara") | C | (2)(3)(4) | Followed path south of Long Island and Nantucket |
| 1953, Sept. 7 ("Carol") | C | (2)(3)(4) | Passed east of Cape Cod heading generally north. |

TABLE C-1 (Cont'd)

| Date of Hurricane | (1) Category | Source of Data | Remarks |
|---|---|---|---|
| 1954, Aug. 31 ("Carol") | A | (2)(3) (4) | Second most damaging storm to hit Conn. coast. Crossed east end of Long Island, moving north. Surge of 5.6 ft. caused flooding to 10.0 ft.msl at Westport. |
| 1954, Sept. 11 ("Edna") | B | (2)(3) (4) | Passed over Cape Cod heading northeast. High seas, minor damage from wind. |
| 1954, Oct. 15 ("Hazel") | B | (2)(3) (4) | Heavy rainfall and river flooding in the interior of Conn., Mass., and R.I. negligible tidal flooding along coast. Center moved through western New York. |
| 1955, Aug. 12-13 ("Connie") | C | (3)(4) | Caused scare in New England and heavy rainfall but no damage. Storm passed southwest of Washington, D.C. |
| 1955, Aug. 18-19 ("Diane") | B | (2)(3) (4) | Passed just south of Long Island and about over Nantucket. Brought record rainfall to many areas of Conn.; heavy flood damages in river valleys; no tidal-flood damage along coast. |
| 1955, Sept. 20 ("Ione") | C | (3)(4) | Caused scare in New England but no reported damage. Storm turned east and then northeast after passing inland of Cape Hatteras. |

TABLE C-1 (Cont'd)

| Date of Hurricane | Category | Source of Data | Remarks |
|---|---|---|---|
| 1958, Aug. 29 ("Daisy") | C | (3)(4) | Caused scare in New England but no damage. South of Nantucket Island the storm turned east and then north-easterly. |
| 1960, July 30 ("Brenda") | B | (3)(4) | Storm crossed coast just west of Bridgeport and continued into western Conn. and Mass. Some minor wind damage; negligible tidal flooding. |
| 1960, Sept. 12 ("Donna") | B | (3)(4) | Storm crossed coast near New London continued over Worcester, Mass. and into N.H. Tides 4 to 5 feet above normal along southern coast of New England caused flood damage at a number of localities. |

Notes

(1) The following assigned categories pertain to the effect of a hurricane on the coast of Connecticut
- A: Caused severe tidal flooding.
- B: Caused damage from wind or rainfall(usually accompanied by high seas and moderate tidal flooding).
- C: Threatened area

(2) "Hurricanes - Their Nature and History," By I.R. Tannehill (1956)

(3) Local newspaper accounts, histories, etc.

(4) Material furnished by U.S. Weather Bureau.

C-3. DESCRIPTIONS

Brief descriptions of type "A" and type "B" hurricanes experienced along the Connecticut coast from 1770 to 1930, as recorded by historians and as reported in newspaper accounts and other records are given below. Also, included are descriptions of four severe hurricanes (Category "A") that are reported to have struck Rhode Island and Massachusetts prior to 1770 but for which no accounts have been found regarding their effect on Connecticut coastal areas. Subsequent to 1930, numerous and more adequate records are available of storm occurrences, including data on tidal-flood levels, wind velocities, and other storm characteristics.

a. 15 August 1635. From: "Of Plymouth Plantation, 1620-1647," by William Bradford.

"This year the 14 or 15 of August (being Saturday) was such a mighty storm of wind and rain, as none living in these parts either English or Indian, ever saw, being like (for the time it continued) to those Hauricanes and Tuffons that writers make mention of in the Indies. It began in the morning, a little before day, and grew not by degrees, but came with violence in the beginning to the great amazement of many. It blew down sundry 211 houses, and uncovered others; divers vessels were lost at sea, and more in danger. It caused the sea to swell (to southward of this place) above 20 feet, right up and down, and made many of the Indians to climb into trees for their safety; it took off the board roof of a house which belonged to this plantation at Manamet, and floated it to another place, the posts still standing in the ground; and if it had continued long without the shifting of the wind, it is like it would have drowned some part of the country. It blew down many hundred thousands of trees, turning up the stronger by the roots, and breaking the higher pine trees off in the middle, and the tall young oaks and walnut trees of good bigness were wound like a withe, very strange and fearful to behold. It began in the southeast and parted toward the south and east, and veered sundry ways; but the greatest force of it here was from the former quarters. It continued not (in the extreme) above 5 or 6 hours but the violence began to abate. The signs and marks of it will remain this 100 years in these parts where it was sorest. The moon suffered a great eclipse in the second night after it."

From: "The History of New England from 1630 to 1649," by John Winthrop.

"...This tempest was not so far as Cape Sable, but to the south more violent, and made a double tide all that coast...

"The tide rose at Narragansett fourteen feet higher than ordinary and drowned 8 Indians flying from their wigwams."

b. 3 August 1638. From: "The History of New England from 1630 to 1649," by John Winthrop.

> "In the night was a very great tempest of hiracana at S.W. which drave a ship on ground at Charlestown, and brake down the windmill there, and did much other damage. It flowed twice in 6 hours and about Narragansett it raised the tide 14 to 15 feet above the ordinary spring tides upright."

c. 30 October 1723. From: "The Boston News-Letter, No. 1032...From Thursday, October 31, to Thursday November 7, 1723."

> "Rhode Island, November 1 .....
> "...On Wednesday last we had here a very great South East storm of Wind & Rain, and a very high Tide, a Foot higher than ever was known before, which has broken & carried away several of our Wharfs, and drove some vessels ashore from their anchors and has done considerable damage in Warehouses and Cellars, to dry goods, and other merchandize: the Loss is computed to some thousand pounds...."

d. 24 October 1761. From: "The Boston News-Letter, No. 2991. Thursday, October 29, 1761."

> "Last Friday evening between 8 and 9 o'clock came on the severest N.E. Storm of Wind and Rain that has been known here for 30 Years past, and continued 'till between 2 and 3 o'clock next Morning;...Five or six Vessels were drove ashore at Providence in Rhode Island Government, and greatly damag'd and it being high Water there it got into the Stores and Cellars and damag'd Sugars &c to the amount of 12 or 15,000 (pounds) their Currency; it has also entirely carried away the great Bridge at that Place. - On both roads East and West, so far as we have heard, the Roofs of Houses, Tops of Barns, and Fences, have been blown down, and it is said Thousands of trees have been torn up by the Roots by the violence of the above storm, and we fear we shall hear melancholy Accounts of Damage done at Sea."

From: "The Newport Mercury."

"On Friday last came a terrible storm from the Northeast, which continued increasing with a very heavy rain, and did not abate till after 2 in the morning. The violence of the wind broke off part of the steeple of Trinity Church. Several persons sustained considerable loss in their sugar, salt, etc. by the prodigious rise of tide, which flowed into their stores and cellars. Many of the ships in the harbor were driven ashore from the wharves and their moorings, but without any considerable damage except to two ships. Sad havoc has been made with the lumber and wood on the wharves, great quantities of fence blown and numbers of trees torn up by the roots. People hardly thought themselves safe in their own houses, for a more violent storm has scarce ever been known here."

e. 19-20 October 1770. (Type "A"). "History of the State of Rhode Island," by Samuel Greene Arnold.

"A violent storm again blew down a part of the spire of Trinity Church at Newport and caused an immense loss of life and property along the coast. Newport suffered very severely in this gale."

From: "The Connecticut Journal," November 21, 1770.

"New London, Oct 26.

"On Friday Night and part of the next Day we had a very Severe Storm of Wind and Rain From the N.E. by which two Vessels were drove ashore in this Harbor but received little or no damage."

f. 19 September 1787. (Type "B"). From the diary of William Wheeler in "Black Rock, Seaport of Old Fairfield, Connecticut, 1699-1870."

"Line storm. A mill at Stamford carried off whole and Norwalk bridge floted."

g. 19 August 1788. (Type "B"). From the diary of William Wheeler in "Black Rock, Seaport of Old Fairfield, Connecticut, 1699-1870."

"The hardest gale that has been for many years--at 1 o'clock a Sloop & Schooner went on shore---. The Gale reached 100 miles up country, in some places shifting from SE to NW & twisting of trees 9 inches in diameter--it moved Carson's house about 6 feet."

From: "The New Haven Gazette and The Connecticut Magazine," Thursday, August 21, 1788.

"New Haven.

"Last Tuesday morning came on a violent gale of wind from the South which at about one o'clock P.M. veered to S.S.W. and blew a perfect hurricane.

"Several vessels were driven ashore and very material damage is done to the long Wharf...We expect to hear of much damage done at sea and in the harbours on our coast...."

From: "The Connecticut Courant and Weekly Intelligence," Monday, August 25, 1788.

"New Haven, Aug. 20.

"Yesterday we had a violent gale of wind, the height of which was from the S.E. about one o'clock. Though the tide was not full as has been frequent in easterly storms, considerable damage was done to the Long-Wharf by the violence of the waves and several vessels parted their masts, but the shipping received no material damage. The Indian corn is much injured and the trees stripped of their fruit and some apple trees blown down."

h. 9-10 October 1804. (Type "B"). From: "The Connecticut Courant," October 17.

"The partial and summary accounts which have been received from the neighboring towns, though they afford no particulars of the effects of the late gale, sufficiently evince the widespread destruction which has been experienced by it. In almost every direction the fruit and other trees have been generally blown down, the fences destroyed and much damage done by the heavy rain, which fell during the storm."

i. 22-23 September 1815. (Type "A"). From: "Connecticut Herald," New Haven, September 26.

"The storm--On Friday night and Saturday morning last a severe storm of wind and rain was experienced in this vicinity...The most material injury sustained here was to Long Wharf, which was entirely inundated by the highest tide known for a great number of years. Everything movable on the wharf was swept away. The water in some of the stores was nearly two feet deep, but no great loss of property took place except in a quantity of rum which was swept from the wharf, several hogshead of which have not yet been recovered..."

From: "The Connecticut Courant," October 4.

"Bridgeport, Sept. 27.

"The late Storm which commenced on Thursday last continued with increasing violence until 11 o' clock on Saturday morning. The wind during the whole time blew a severe gale accompanied with rain from the N.E. and had so much increased the waters in the Sound that the tide, which in ordinary weather would have been full at 2 o'clock and 44 minutes, attained its greatest height at 12 o'clock 30 minutes, and was then near six feet above common flood tides; and had it not fortunately happened that the wind some hours before the tide was at full veered round to the N.W. it must have risen to an alarming height. The oldest inhabitants do not remember so high a tide by nearly one foot. The water through the whole length of Water Street was of sufficient depth for the largest long boat to pass loaded with passengers. Considerable damage has been sustained in the stores along the shore by the destruction of salt, grain and other bulky articles that could not speedily be removed.

From: "Connecticut Herald," New Haven, October 5,1815.

"The late storm has done incalculable damage to roads and bridges, especially on the sea coast, where the tides assisted its destructive power. No mail from Boston has arrived since Saturday last, undoubtedly owing to the road being damaged, and the bridges carried away. An old citizen of New Haven who has been particularly attentive to the subject has informed us that forty-five years ago there was a remarkable high tide in this town which did not, however, rise as high by four inches, as the one on Saturday last.--Had not the wind, two hours and a half before high water, suddenly shifted to the westward, it is impossible to tell what damage might have been sustained by inhabitants on the Sound."

j. 3 September 1821. (Type "A"). From: "Connecticut Herald," New Haven, Tuesday, September 11.

"We were visited in the evening of the 3d inst. by a toronado almost unexampled in this latitude. The gale commenced at S.E. about 6 o'clock but was most violent from 8 - 10, the wind then varying from S.S.E. to S.W.-- nearly all vessels in the harbor were driven by the force of the storm, and are more or less damaged...Fortunately

at the height of the gale it was time of low water; otherwise, damage to shipping, wharves, stores &c, must have been incalculable...The rafters and gable end of a brock store on the wharf... were blown down... part of the roof of Mr.Thomas Hunt's dwelling in Water St. was torn off...scarcely a street was exempted from falled chimnies and fences. Several trees were upturned by the roots...the leaves of most of which remain are changed to a singular dark brown hue.

"Part of the first bridge on the pier was carried away by the driving of a sloop, who struct upon her stem.

"At Bridgeport, several buildings were blown down or unroofed....Almost all the vessels in port were driven ashore, but without much injury.

* * *

"New London, September 5.

"Severe Gale.---On Monday night last we experienced a severe gale from the South-East. It commenced at 7 in the evening and lasted until midnight. The tide rose several feet above its ordinary level and some damage was done to our wharves and boats..."

From: "Black Rock, Seaport of Old Fairfield, Connecticut, 1699-1870."

"A tremendous gale of wind E and SE from 6 to 11 in the evening passed over this place--tore down many--trees... every vessel went ashore in this harbor---A sloop dismasted in the sound and the lighthouse laid flat. The hardest gale ever remembered.

"The leaves of the trees as in 1788 are turned brown...small limbs of trees blew thirty rods---there was a continual roaring like thunder..."

k. 2-3 October 1841. (Type "B"). From: "Hartford Daily Courant," Tuesday, October 5.

"Severe Storm--We have been visited by a most remarkable storm--the like of which, so early in the season, on account of its severity and continuance, is not remembered by our oldest inhabitants. On Saturday night it commenced raining, the wind from the northeast, and continued without intermission, intermingled a part of the time with snow and accompanied by wind until sometime yesterday afternoon. During a part of Sunday night, the wind blew a perfect hurricane, and the rain

came down in torrents...Many valuable fruit and ornamental trees have been prostrated or stripped of their limbs...as the storm undoubtedly extended along the coast, we may expect to hear of damage from that quarter."

l. 29-30 October 1866. (Type "B"). From: "Hartford Daily Courant," October 31.

"One of the hardest storms of the season prevailed on Monday and continued through yesterday. It was a regular southeaster---one of those violent storms that often haunt us at this season of the year....The wind prostrated the lines between New Haven and New York and at other places east and south. The steamer Granite State left New York at the usual hour on Monday and met with rough weather on the Sound...."

m. 8 September 1869. (Type "A"). From: "Norwich Morning Bulletin," September 12, 1869.

"Storm (at Mystic, Conn.) worst since 1815. Came at low water and the tide, though rising higher than it has for 2 or 3 years, did less damage than it otherwise would have done. Had it occurred at highwater, the bridge and a large part of Mystic would have submerged. The tide rose at the rate of an inch a minute, walling up a foot high where it struck the spiles at the bridge."

n. 22-23 October 1878. (Type "A"). From: "The Daily Standard, Bridgeport, October 23, 1878.

"A section of the fence...opposite the depot blew down this morning.

"A portion of the bulletin board corner High and Main Streets blew down this morning. Limbs were broken off the trees in all sections of the city.

"The storm last night and this morning drove a number of small boats ashore below the Naugatuck dock and their owners turned out and dragged them beyond reach of the waves....

"The sea held high carnival at Sea Side Park this morning, and a wilderness of rolling white caps and tempest of dashing spray bore witness to

the disturbed mood of the waters, angered by the howling winds..."

From: "Greenwich Observer," October 24, 1878

"...The storm yesterday was very severe and the shipping in our harbor was roughly tossed. The tide rose to a remarkable degree..."

From: "The Daily Standard," Bridgeport, October 24, 1878

"New Haven, Oct. 23d,---The steamer John Bramhall, Captain Pollard, from this city, ashore on Little Cull Island, has gone to pieces in the gale."

o. 10 December 1878. (Type "B"). From: "The Providence Daily Journal," Providence, Rhode Island, Wednesday, December 11, 1878.

"Yesterday was a rainy day*** and the wind blew mightily from the southeast in fitfull gusts***. Toward evening the wind increased in fury and power***. The wind did not decrease in volume or strength until 6:00 and the rain fell as rapidly as during the day.

"**. A floating bath house above India Bridge (Providence) was blown from its mooring. A ship broke loose. Cellars flooded, some up to 8 inches.

"The water in the river (Providence River) rose very high, higher than before this year*****. Fortunately the wind went down about an hour before high water and danger was averted. This is the second time this year in which the gale ceased an hour or so before high tide. Water washed over the Dorrance Street wharf. Dyer Street cellars got a little water."

"Hartford, Conn., December 10 - The storm and gale was very severe here this afternoon and at its height about 6:00 o'clock. Several chimneys were blown down and buildings unroofed."

p. 18 August 1879. (Type "B"). From: "Stamford Herald," (Weekly) August 20.

"---From a test made at Waterside the rainfall during the last storm was found to be 8 inches. On Monday from 7 a.m. till 7 p.m. a little over 4-1/2 inches fell.

"A more soaking continuous and persistent rainstorm we have seldom experienced in August...Corn has suffered under the infliction of so much rain and wind..."

q. 10 September 1889. (Type "B"). From: "The Greenwich News," Friday, September 13.

"The furious northeaster which has been raging along the Atlantic Coast for the past few days is one of the severest storms known in this vicinity for years, and one of the most destructive to property. Ever since Tuesday when the storm reached here from the Atlantic, it has blown a gale, mostly from the northeast, accompanied nearly all of the time by rain.

"The greatest force of the storm has been felt along the coastline...small craft along the shore have suffered severely...

"Greenwich has suffered comparatively little from the storm. A few trees have been blown down and the roads have been damaged more or less, but beyond this there was scarcely any damage done. On Tuesday there was a very high tide in the harbor and at one time part of the steamboat dock was under water...the only loss reported along the shore are one or two row boats."

* * *

"The schooner Annie Jacobs from New Haven... was beached on Mansuring Island during the storm Tuesday night."

From: "The Greenwich Opinion, September 20.

"The crib dock which Mr. J.D. Barrett has erected on his property at Belle Haven was washed away by last week's storm.

r. 23-24 August 1893. (Type "A") From: "Stamford Advocate," August 24.

"One of the most severe storms of wind and rain ever experienced in this locality started last night and continued increasing in force until this forenoon. The evidences of its severity were to be seen on every hand...streets washed out and flooded, buildings damaged...

"...Every boat in the harbor was adrift...The tide rose higher than has been known for some time. All the

streets in the vicinity of Waterside were impassable, the water coming up over the meadows to the foot of Atlantic Street...

"The scene in the lower harbor at high tide this morning was a wild one...On the whole the craft in the lower harbor escaped well, much better probably than they would have done had a gale of equal force come in from the southwest."

s. 29 August 1893. (Type "B") From: "The Day," New London, Connecticut, Tuesday, August 29, 1893.

"The storm today has been free from some of the disagreeable accompaniments that made last Thursday's blow one of the worst experienced in this vicinity in recent years.***

"The tide was very high all the morning, nearly up to the string pieces on the bulkheads and almost washing the timbers of the deck of the railroad bridge at the upper end of town.

"Down at Ocean Beach the scene today was grandeur, if possible, than last week. The surf was heavier and there was much more of it. It rolled in way up to the embankment, great breakers at least 10 feet high washing over the wharf***. Alewife Cove was filled again way to the new road, and things in that locality had about the same appearance as last week."

t. 9-10 September 1896. (Type "B") From: "The Providence Daily Journal," Providence, Rhode Island, Thursday, September 10, 1896.

"The storm which began yesterday morning, came unheralded, as all northeast storms do******.

"The storm was a most peculiar one, for while the wind was offshore the sea was constantly increasing, and at nightfall it dashed in upon the rocky shore and the spray being thrown fully 25 feet in the air.

"At Block Island the storm was considered the severest on record at this season of the year. Late in the afternoon the wind velocity was recorded at 76 mph with no signs of abating."

u. 16 September 1903. (Type "B"). From: "The Bridgeport Daily Standard," September 17.

"Very strong winds and rain unroofed houses, felled or uprooted trees.

"...a casual survey of the damage along the waterfront shows it will run into the thousands...

"At the Bridgeport Yacht Club in the Black Rock Harbor there was damage galore, and but for the active work of the yachtsmen there would have been several fine yachts totally wrecked.

"Although the waves were very high the water did comparatively little damage...no water ever reached the roadway although everybody was completely drenched with the spray which rose in a long continuous, heavy white cloud the whole length of the sea wall."

*****

"New Haven, September 17. Wind, rain and a phenomenally high tide combined to make the damage in and about New Haven very expensive.

"The bathing pavilion in the rear of Mrs. Albert Wintter's residence at 313 Seaview Avenue was blown in the water."

From: "The Daily Advocate," Stamford, September 16.

"The storm which is raging all over this section struck Stamford with a vengeance at noon today and inside of an hour it had shaped itself into what old-timers say, is the swiftest easterly storm experienced for twenty years or more.....

"On the east shore of Shippan, the storm was felt with great severity, and the same is true of Sound Beach where there are a number of summer cottages near the shore.

"The wind blew great guns...rain fell in veritable sheets. On exposed corners this was particularly noticeable, the pavements being under a constant wash of water... The wind came from the east and blew at from 75 to 80 miles an hour."

v. 15 September 1904. (Type "B"). From: "New Haven Evening Register," September 15.

> "At one time early this morning, shortly after midnight the wind being then at the southwest, blew at the rate of 40 miles an hour...During the entire progress of the storm in New Haven 3.96 inches of rain fell...At Casey Beach, during the early part of the storm, the shore was heavily lashed by angry waves and for a time it seemed as though some of the lighter of the houses would be thrown from their foundations. Then the wind shifted and blew offshore and the water smoothened...Trees were uprooted and oyster beds damaged by the winds...."

w. 13 November 1904. (Type "B"). From: "New Haven Evening Register," November 14.

> "Here in New Haven the wind in yesterday's gale blew as high as 50 miles an hour. Many telephone and telegram wires were prostrated and there was some light wreckage about the harbor..."

x. 30 Sept. - 1 Oct. 1920. (Type "B"). From: "The Daily Advocate," Stamford, October 1.

> "The wind attained a velocity of 60 miles an hour, and it roared along the shorefront in an alarming manner, but did no great actual damage there. It veered from south by east, late in the afternoon to a more southerly direction as to the night wore on. Its greatest velocity was attained about midnight. That was sufficient to rock some houses on their foundations.
>
> "Boats were torn from their moorings and trees were blown down."

* * * *

> "Norwalk, Oct. 1--Last night's storm here was the worst in years, doing damage along the Sound shore. The tide reached a record height at 1 a.m., the water covering the roads and wrecking a number of cottages at Belle Island...12 small boats were carried ashore and wrecked... and much damage done by the wind."
>
> "New Haven, Oct. 1. Thousands of dollars of damage was done along the Sound shore last night by one of the worst storms in several years. Driven by a gale which exceeded 40 miles from the southwest and accompanied by

a high tide. The waves rolled mountain high against the beach during the night, the tide reaching a record height about midnight. Many boats were washed ashore, cottages, piers and breakwaters being partially wrecked.

"At the Weather Bureau this morning it was stated that the wind reached a velocity of 42 miles at the height of the storm. A total rainfall yesterday and last night of 2.51 inches was recorded."

y. 26 August 1924. (Type "B"). From: "Standard Sentinel," August 27.

"Nothing like the devastation of felled wires, cables and poles in the eastern part of the State ever has been experienced by the telephone people..."

* * * *

"New Haven, Conn. Aug. 27.--With approximately 6,000 telephones out of commission in the territory east of Saybrook, a section of the State severely hit by a juvenile toronado late yesterday afternoon the Southern New England Telephone Company suffered more damage than...in a great many years..."

z. 2 October 1929. (Type "A"). From: "New Haven Journal-Courier," October 3.

"Damage which will probably total thousands of dollars was done yesterday along west shore in Milford by the lashing northeaster which swept northward from the Caribbean..its ferocity had been largely spent by the time it had reached the shores of Long Island Sound...

"The largest damage reported from along the shore yesterday came from Silver Beach in Milford where the strong northeasterly and easterly gale created waves at the high tide hour this morning which tossed one cottage off its foundations....

"The water overflowed the trolley tracks and in some places covered the Milford shore road to a depth of two feet...the storm concentrated its fury on the Milford shore...

"High tides came near flooding street car tracks where they pass close to the water's edge on the shore runs, it was said, but no delays were brought about by this cause.

"Official figures...for total rainfall...of 2.03 inches between 8 p.m. and 8 a.m. yesterday and precipitation for the 12 hours after 8 a.m. yesterday being 1.30 inch.

"The wind velocity at both 8 a.m. and 8 p.m. was 12 miles per hour atop the post office building, but reports had velocities of 25 miles an hour at Milford."

* * * *

C-4. HURRICANE TRACKS

The tracks of four notable hurricanes causing tidal flooding and serious damages along the Connecticut coast, namely, those of September 1815, September 1938, September 1944, and August 1954, are shown on Plate C-1. The path of Hurricane "Diane," (1955) a storm which brought record rainfall to many areas in southern New England, is also shown on the Plate.

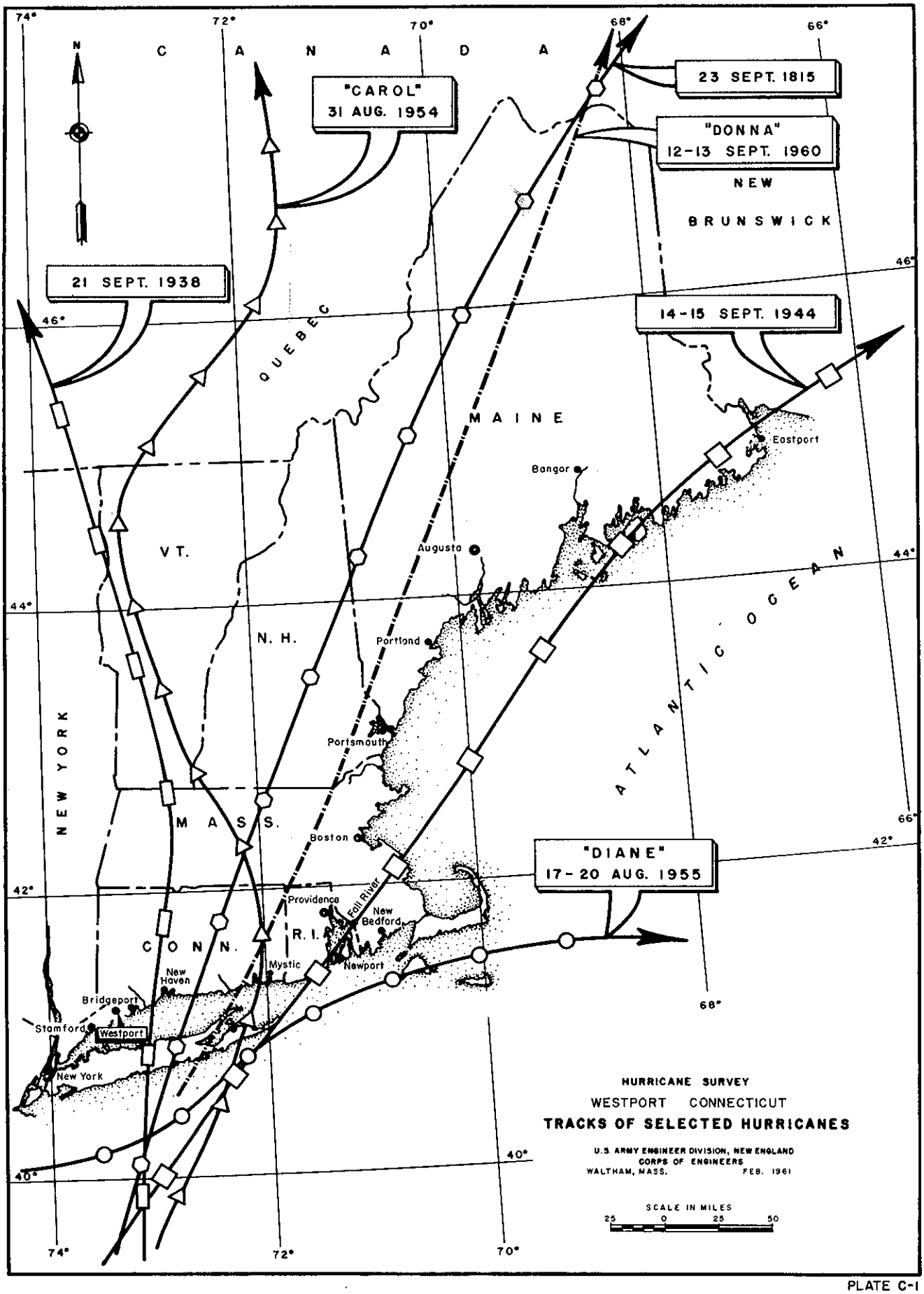

N
C A N A D A
"CAROL"
31 AUG. 1954
23 SEPT. 1815
"DONNA"
12-13 SEPT. 1960
NEW
BRUNSWICK
21 SEPT. 1938
14-15 SEPT. 1944
QUEBEC
MAINE
Eastport
Bangor
Augusta
VT.
N. H.
Portland
Portsmouth
ATLANTIC OCEAN
NEW YORK
MASS.
Boston
"DIANE"
17-20 AUG. 1955
Providence
Fall River
New Bedford
CONN.
R.I.
Mystic
Newport
New Haven
Bridgeport
Stamford
Westport
New York
74°
72°
70°
68°
66°
46°
44°
42°
40°
HURRICANE SURVEY
WESTPORT CONNECTICUT
TRACKS OF SELECTED HURRICANES
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. FEB. 1961
SCALE IN MILES
25 0 25 50

PLATE C-1

# APPENDIX D

# FLOOD LOSSES AND BENEFITS

# APPENDIX D

## FLOOD LOSSES AND BENEFITS

### GENERAL

### D-1. DAMAGE SURVEY

A preliminary damage survey of the Long Island Sound and Saugatuck River tidewater areas of Westport was made in the fall of 1956 and reviewed in 1960. The survey consisted largely of door-to-door interviews and inspections of the various residential, commercial, public, and industrial properties in the flooded areas of the town along Long Island Sound and along the Saugatuck River downstream from Kings Highway North. Information obtained included the extent of areas flooded, descriptions of properties, including economic and physical changes since the 1954 hurricane, the nature and amount of damages, depths of flooding, high-water references, and relationships between the August 1954 flood level and other tidal-flood stages. Damage estimates and depths of tidal flooding were generally furnished by property owners or tenants. Investigators prepared alternate estimates when, in their judgment, estimates of owners or tenants were unrealistic or unreliable. The investigators also made estimates where information was not available from owners or tenants. Sampling methods were used where several properties of similar type were subject to the same depth of flooding. Data on damages to public property, utilities, and highways were obtained, whever possible, from central sources and applied to the field information.

Sufficient data were obtained to derive loss estimates for (1) the August 1954 flood stage, (2) a stage 3 feet higher, and (3) intermediate stages where marked increases in damage occurred. The stage at which damage begins, referenced to the August 1954 flood stage, was also determined.

### D-2. LOSS CLASSIFICATION

Flood loss information was recorded by type of loss and by location. The types of losses recorded included urban (residential, commercial and public), industrial and highway.

Primary losses were evaluated, including (1) physical losses, such as damage to structures, machinery, equipment and stock, and cost of cleanup and repairs, and (2) non-physical losses, such as unrecoverable losses of business and wages, increased cost of operation, and the cost of temporary facilities. These losses were determined by direct inspection of flooded properties and evaluation by property owners, field investigators, or both. Where necessary, the nonphysical losses were estimated by utilizing relationships between physical and nonphysical losses for similar properties in the survey and other areas.

## HURRICANE TIDAL-FLOOD DAMAGES

### D-3. TIDAL-FLOOD LOSSES

The hurricane tidal surge accompanying Hurricane "Carol" on 31 August 1954 occurred nearly coincident with the peak of a high gravitational tide and caused serious flooding in the town of Westport. Tidal flooding in 1954 rose 6.2 feet above mean high water, reaching a level of 10.0 feet msl or 0.5 foot below the record tidal-flood height experienced in 1938. The tidal-flood damages in Westport, in August 1954, amounted to $940,000. Approximately 450 structures, three public beaches and several town roads suffered flood damages. The damage areas are described in Table D-1 and are shown on Plate D-1.

### D-4. TYPE AND DISTRIBUTION OF EXPERIENCED LOSSES

The major damage was sustained by residential properties. Approximately 380 homes and summer cottages suffered an estimated loss of $740,000, which represents nearly 80 percent of the tidal-flood damage in the town. About one-third of this loss was damage to seawalls. A tabulation of 1954 experienced tidal-flood losses in Westport, by damage area and by type of loss is shown in Table D-1.

Area I, the largest of the five areas subject to tidal-flooding, sustained losses of $275,000. Nearly all of this loss occurred as erosion damage to the seawalls and grounds of eight large private estates in the Green Farms area, with lesser damage at Burial Hill Beach. Twenty cottages in the Sherwood Island State Park area and the grounds at both the State Park and the town-owned Alvord Beach experienced minor flood damage.

TABLE D-1

EXPERIENCED TIDAL-FLOOD LOSSES

HURRICANE "CAROL", 31 AUGUST 1954

Westport, Connecticut

| Area | Description | Losses in Thousands of Dollars | | | | | |
|---|---|---|---|---|---|---|---|
| | | Residential | Commercial | Public | Industrial | Highway | Total |
| I | Fairfield town line (Sasco Brook) to Compo Cove | 275 | - | * | - | - | 275 |
| II | Compo Cove to east abutment of New Haven Railroad bridge (Saugatuck River) | 225 | * | 25 | - | 10 | 260 |
| III | East bank of Saugatuck River upstream of railroad bridge | 15 | 85 | 15 | - | - | 115 |
| IV | West Bank of Saugatuck River upstream of railroad bridge | 25 | 55 | * | 10 | - | 90 |
| V | West bank of Saugatuck River downstream of railroad bridge to Norwalk town line | 200 | - | - | - | - | 200 |
| | Total | 740 | 140 | 40 | 10 | 10 | 940 |

(*) Asterisks indicate losses less than $5,000

Losses in the Compo Beach-Owenoke Park area, Area II, amounted to $260,000. About 85% of this loss was occasioned by the flooding of buildings and grounds of some 220 summer and year-round residences at Compo Beach and Owenoke Park. The balance of the loss in this area consisted of damage to 11 other homes, highways, a restaurant, and town-owned bathhouses and yacht club, and cabanas at a country club which has subsequently been purchased by the town for public recreational purposes.

Tidal flooding in Area III, which includes the main business district of Westport, caused damages amounting to $115,000. Nearly 75 percent of this loss was sustained by 42 commercial establishments, many of which had a foot of water covering their main floors. Eighteen homes in this area, a library, and the YMCA experienced flooding.

The tidewater area along the west bank of the Saugatuck River, upstream of the New Haven Railroad bridge, Area IV, suffered an estimated $90,000 loss. About 60 percent of this loss was sustained by 18 commercial establishments, of which eight had up to two feet of water on their ground floors. Twenty-three homes, three small industrial firms, and a fire station also experienced flooding.

Losses in Area V, the residential area along the west bank of the Saugatuck River, downstream of the railroad bridge, amounted to over $200,000. Hardest hit was the Saugatuck Shores area where 86 homes experienced flooding. Serious erosion damage occurred in the one-mile reach between Saugatuck Shores and the railroad. In this reach are 17 large homes and estates which sustained damages to grounds and seawalls. The residence on one large estate suffered first-floor damage.

## D-5. RECURRING LOSSES

There has been essentially no change in the properties in the flood area since the 1954 hurricane. A recurrence of the 1954 tidal-flood stage in Westport would cause damages amounting to $1,070,000 at 1960 price levels. A tabulation of the tidal-flood losses that would be sustained in future hurricanes is shown in Table D-2. Losses are shown for the entire town and for the Compo Beach area behind the recommended protection.

TABLE D-2

RECURRING TIDAL-FLOOD LOSSES

Westport, Connecticut

| Equivalent Hurricane | Flood Stage (feet msl) | Losses (1960 Price Level) Entire Town | Compo Beach Protected Area |
|---|---|---|---|
| 21 Sept 1938 | 10.5 | $1,400,000 | $290,000 |
| 31 Aug 1954 | 10.0 | 1,070,000 | 230,000 |
| 14 Sept 1944 | 9.1 | 540,000 | 130,000 |

## ANNUAL LOSSES AND BENEFITS

### D-6. GENERAL

The total benefit of the plan to control tidal flooding in the residential area at Compo Beach, up to the record hurricane tidal-flood level of 10.5 feet, msl, consists of flood-damage prevention benefits less a small residual annual loss which would result from fresh water ponding behind the protection. No significant benefits will accrue from the enhancement of property values in this area or from the elimination of emergency costs incurred by temporary measures undertaken during a hurricane threat.

### D-7. AVERAGE ANNUAL TIDAL-FLOOD LOSSES

Recurring losses at various hurricane tidal-flood stages in Westport have been converted to average annual losses to provide a basis for determining the annual benefits to be used in economic evaluation of hurricane tidal-flood protection. The stage-damage data obtained as part of the flood loss survey was correlated with elevation-frequency information to derive damage-frequency relationships for each area where protection plans were investigated. The elevation-frequency curve is based upon observed peak high-water elevations at Westport in the September 1938 and August 1954 hurricanes and supplemented by elevation-frequency data pertaining to Stamford and Bridgeport.

The damage-frequency curve has been plotted with damage as the ordinate and percent-chance-of-occurrence (the reciprocal of frequency) as the abscissa. The area under this damage-frequency curve, see Plate D-2, is a measure of the average annual loss. The average annual loss in the Compo Beach protection area, below an elevation of 13.6 feet msl (a standard project hurricane surge of 9.2 feet on top of a mean spring tide at 4.4 feet msl) equals $50,000 at 1960 price level. Below the design hurricane tide level of 10.5 feet msl, the record level experienced in 1938, this loss amounts to $41,300.

## D-8. ANNUAL FLOOD-DAMAGE PREVENTION BENEFITS

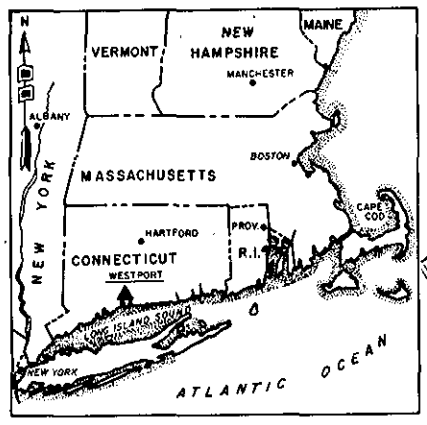
Average annual benefits from the prevention of tidal-flood damages in the Compo Beach area, below the record flood stage of 10.5 feet msl experienced in 1938, is $39,300. This benefit equals the difference between average annual losses of $50,000 under present conditions, below an elevation of 13.6 feet msl, and average annual losses of $10,700 remaining after construction of protective works. The residual loss of $10,700 includes estimated average annual losses of $8,700 resulting from future flooding to stages above the record level experienced in 1938 and estimated annual losses of $2,000 resulting from fresh water ponding behind the protection when the plan is in operation.

## D-9. OTHER BENEFITS

No benefits are anticipated from the elimination of emergency costs incurred during a hurricane threat or from the enhancement of land values. There are no indications of flood prevention measures having been taken upon receipt of hurricane warnings. The protected area is substantially occupied and enhancement of land values or changes in utilities are not anticipated.

CORPS OF ENGINEERS

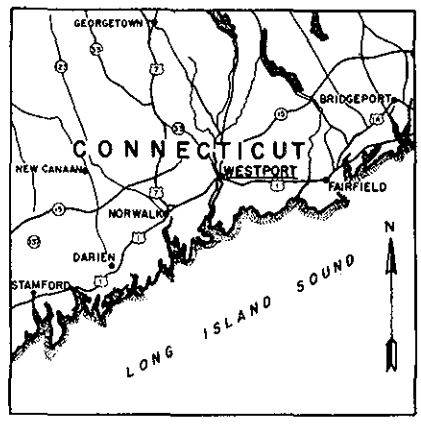
U.S. ARMY




LOCATION MAP

SCALE IN MILES

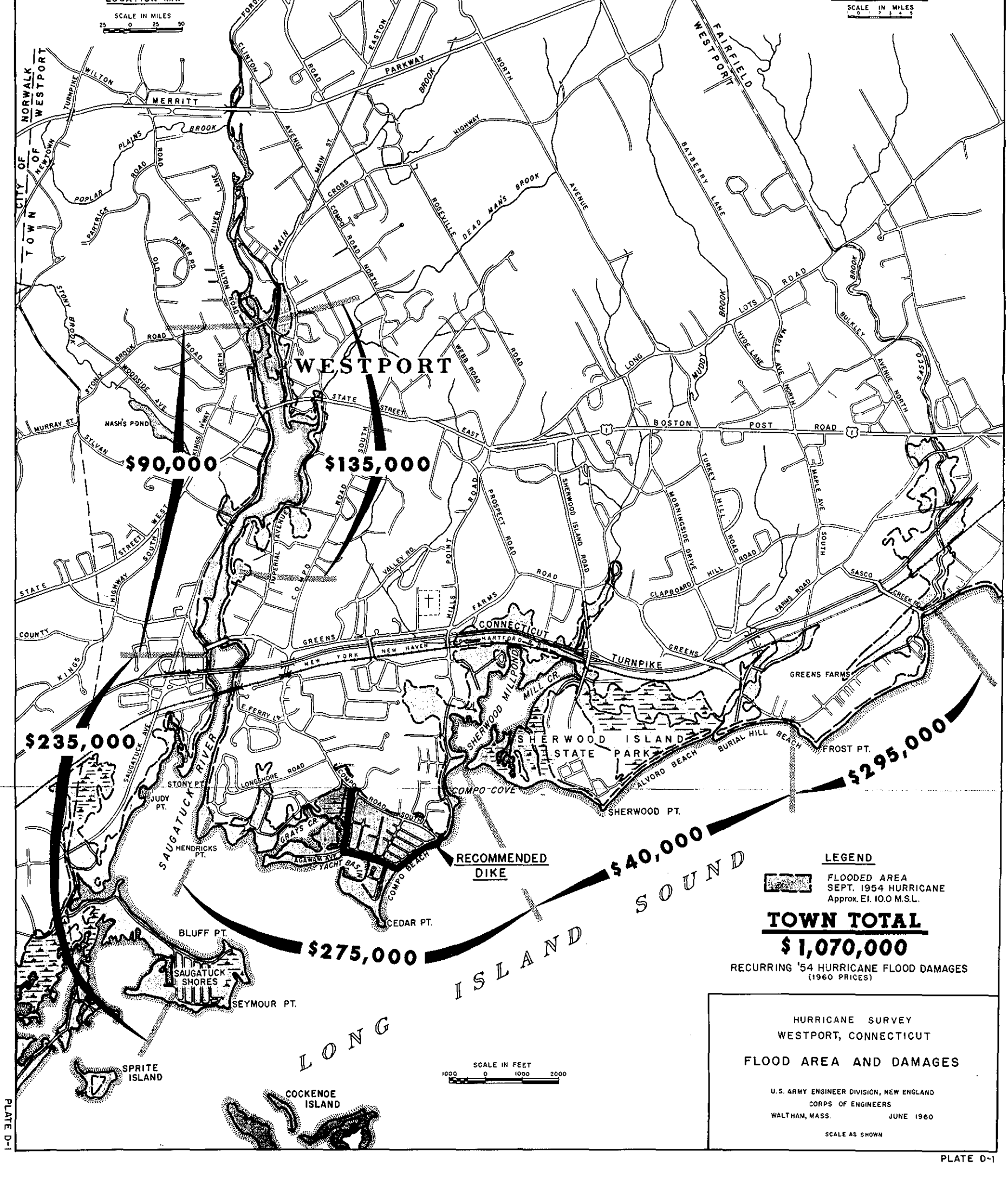
25 0 25 50




VICINITY MAP

SCALE IN MILES

0 1 2 3 4 5




LEGEND

FLOODED AREA
SEPT. 1954 HURRICANE
Approx. El. 10.0 M.S.L.

**TOWN TOTAL**

**$ 1,070,000**

RECURRING '54 HURRICANE FLOOD DAMAGES
(1960 PRICES)

HURRICANE SURVEY
WESTPORT, CONNECTICUT

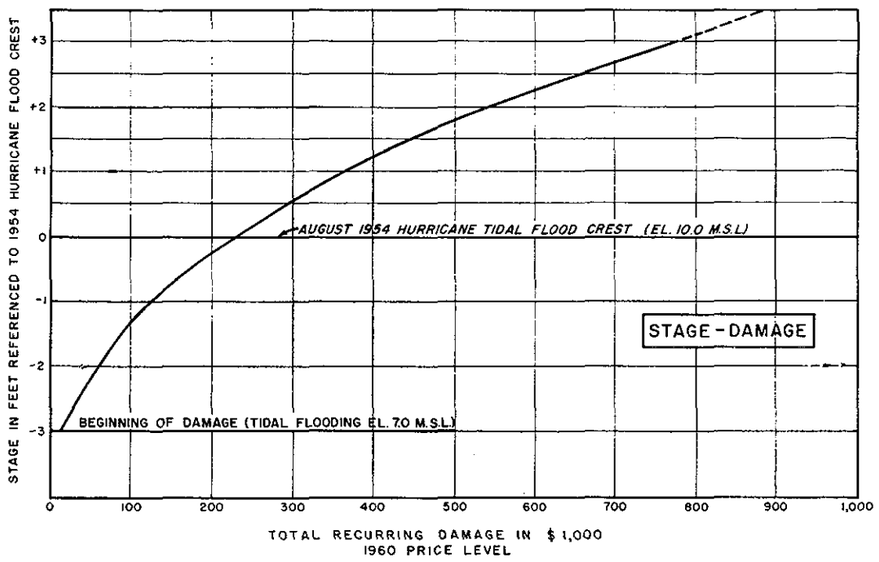
FLOOD AREA AND DAMAGES

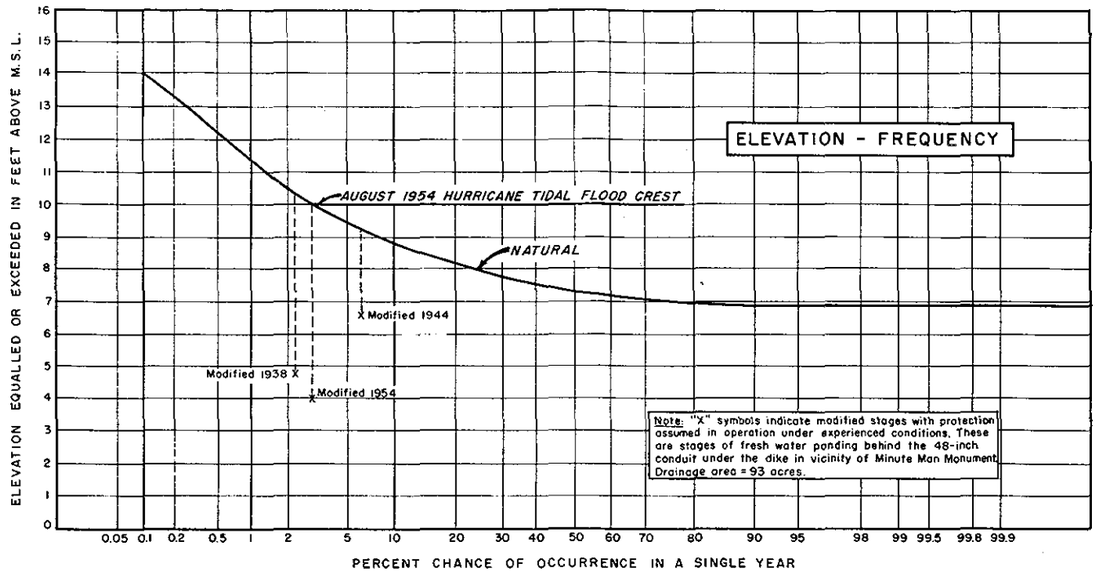
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. JUNE 1960

SCALE AS SHOWN

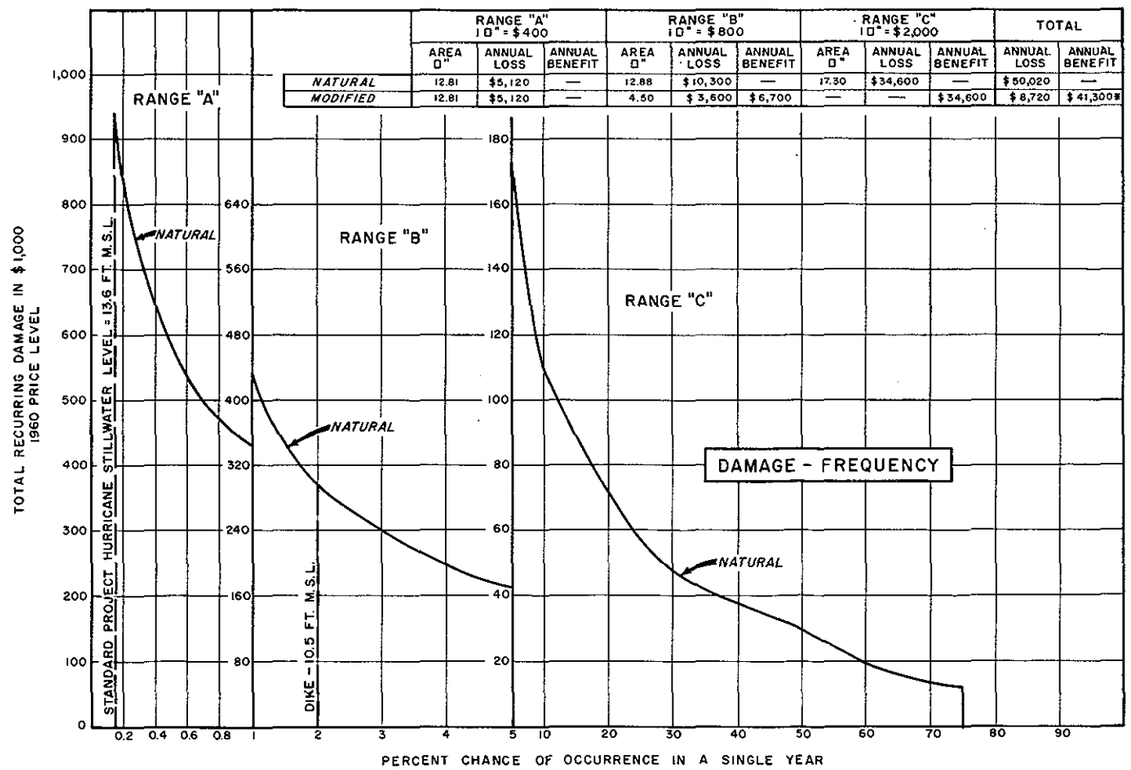
PLATE D-1

PLATE D-1




| | RANGE "A" 1 D" = $400 | | | RANGE "B" 1 D" = $800 | | | RANGE "C" 1 D" = $2,000 | | | TOTAL | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | AREA D" | ANNUAL LOSS | ANNUAL BENEFIT | AREA D" | ANNUAL LOSS | ANNUAL BENEFIT | AREA D" | ANNUAL LOSS | ANNUAL BENEFIT | ANNUAL LOSS | ANNUAL BENEFIT |
| *NATURAL* | 12.81 | $5,120 | — | 12.88 | $10,300 | — | 17.30 | $34,600 | — | $50,020 | — |
| *MODIFIED* | 12.81 | $5,120 | — | 4.50 | $3,600 | $6,700 | — | — | $34,600 | $8,720 | $41,300* |




* Curves shown are predicated on tidal flooding only. Damage from ponding in the Compo Beach residential area begins at elevation 5.0 feet m.s.l. Residual damages from fresh water ponding behind the protection, during periods of operation, are estimated at $ 2,000 annually. The annual benefit of $41,300 from the prevention of tidal flood damages less an estimated annual loss of $2,000 from fresh water ponding gives a net annual benefit of $39,300 for the protection plan.

HURRICANE SURVEY

# WESTPORT, CONNECTICUT
# COMPO BEACH AREA PLAN OF PROTECTION
# CURVES FOR ECONOMIC ANALYSIS

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. FEB., 1961

PLATE D-2
(R-6-14-61)

# APPENDIX E

# DESIGN AND COST ESTIMATES

# APPENDIX E

## DESIGN AND COST ESTIMATES

### INTRODUCTION

E-1. This appendix presents details of design features and cost estimates for the selected plan of hurricane protection for the Compo Beach area at Westport, Connecticut. The principal features of the plan are shown on Plates E-1 and E-2.

### SURVEYS AND EXPLORATIONS

E-2. The design and cost estimates for the selected plan are based on a topographic survey and subsurface explorations accomplished in 1959. Several probings were made along the considered alignment, on the east bank of Grays Creek, to determine the depth of organic overburden.

### DESIGN CRITERIA

E-3. The dike structure has been designed to withstand a design hurricane producing a stillwater elevation of 10.5 feet msl, accompanied by one-foot waves on the left or east bank of Grays Creek from Compo Road to Agawam Avenue, two-foot waves in the area between the Yacht Basin and Compo Beach Road, for 700 feet east of Agawam Avenue, one-foot waves along the south side of Compo Beach Road, for a distance of about 500 feet, west of the intersection with Soundview Drive, and two and one-half foot waves at Compo Beach, along Soundview Drive. Elevations varying from 11.0 to 13.5 feet msl were selected for the top of the dike in order to provide protection against the design hurricane still-water level and design waves. In the case of a design wave breaking against the dike at the time of peak flooding, the overtopping would not appreciably reduce the effectiveness or safety of the structure. For detailed discussion of the design hurricane and wave overtopping see Appendix B.

### SELECTED PLAN OF PROTECTION

E-4. DESCRIPTION OF PLAN

a. General. The selected plan consists of dike protection for the residential area in Westport bounded by Compo Road South, Compo Beach Road, and Soundview Drive. The protection starts at high ground on the east bank of Grays Creek about 300 feet north of Compo Road South, runs south along the east bank of the creek to Agawam Avenue, a distance of about 2,250 feet, and then easterly,

along the south side of Compo Beach Road, to Soundview Drive, a distance of 1,450 feet. The protection then continues along the east side of Soundview Drive to its intersection with Hills Point Road, a distance of 1,510 feet. See Plate E-1.

The dike north of Compo Road south would be constructed of earth-fill with seeded topsoil on both slopes. It would have a top elevation of 11.0 feet msl and a top width of 10 feet. The dike along Grays Creek and Compo Beach Road, from Compo Road South to Soundview Plaza, would be of earth-fill with rock on the top and seaward slope and seeded topsoil on the landward slope, except for one section, 130 feet long, west of Compo Beach Road and north of Agawam Avenue, which would be of earth-fill with seeded topsoil on the top and both slopes. The dike along Grays Creek, north of Agawam Avenue would have a top elevation of 11.0 feet msl and a top width of 10 feet excepting 130 feet with a top width of 5 feet. East of Agawam Avenue to Soundview Plaza the dike would have a top elevation of 11.5 feet msl and a top width of 10 feet. The dike along Soundview Drive would be of earth-fill with rock on the top and both slopes. It would have a top elevation of 13.5 feet msl and a top width of 10 feet.

The project would require the raising of highway grades at four locations as shown on Plate E-2.

b. Pertinent Data. Pertinent data on the dikes comprising the hurricane protection plan for the Compo Beach area is summarized in Table E-1 on the following page.

TABLE E-1

PERTINENT DATA ON DIKES

HURRICANE PROTECTION PLAN FOR COMPO BEACH AREA

Westport, Connecticut

Location: North of Compo Road South

Type: Earth-fill, seeded topsoil on top and both slopes

| | |
|---|---|
| Length | 300 feet |
| Top elevation | 11.0 feet msl |
| Top width | 10 feet |
| Average height | 3.5 feet |
| Side slopes | 1 on 2.0 |

Location: West and south of Compo Beach Road

Type: Earth-fill, rock on top and seaward slope, seeded topsoil on landward slope

| | |
|---|---|
| Length | 2,860 feet |
| Top elevation | 11.0 - 11.5 feet msl |
| Top width | 10 feet |
| Average height | 5 feet |
| Side slopes | 1 on 2.0 |

Location: West of Compo Beach Road and north of Agawam Avenue

Type: Earth-fill, seeded topsoil on top and both slopes

| | |
|---|---|
| Length | 130 feet |
| Top elevation | 11.0 feet msl |
| Top width | 5 feet |
| Average height | 2.5 feet |
| Side slopes | 1 on 5 |

TABLE E-1 (Cont'd)

Location: Along Soundview Drive, at Compo Beach

Type: Earth-fill, rock on top and both slopes

| | |
|---|---|
| Length | 1,510 feet |
| Top elevation | 13.5 feet msl |
| Top width | 10.0 feet |
| Average height | 4.5 feet |
| Side slope, seaward | 1 on 1.5 |
| Side slope, landward | 1 on 2.0 |

## E-5. MODIFICATION TO SEWERAGE AND DRAINAGE FACILITIES

No modification to existing sewerage facilities would be necessitated by the proposed construction. All existing drainage lines which pass under the proposed dikes would be strengthened or replaced where necessary to carry the added weight of the structure. Several new drainage lines would be installed under the dikes to maintain present drainage conditions. Some minor grading and additional catch basins would be required. All lines passing under the dikes would be provided with flap gates on the seaward side of the dikes, and mechanically operated sluice gates on the landward side, to prevent the entry of tidal-flood waters.

All of the conduits under the dikes are sized to discharge a 100-year rainfall, when gates are open. They would be equal to or greater in cross-sectional area than existing drainage lines. The minimum diameters for the conduits under the dikes would be 12 inches for lengths less than 30 feet and 15 inches for lengths over 30 feet. The conduit under the dike near the intersection of Compo Beach Road and Compo Road South would have a diameter of 48 inches to take the runoff from 93 acres, including 53 acres north of Compo Road South and 40 out of the total of 61 acres of protected area south of Compo Road South. The present conduit under Compo Beach Road in this vicinity is 24 inches in diameter. The conduit handling the runoff from the six-acre drainage tributary to the low area in the vicinity of Quentin Avenue at Compo Beach Road would be 18 inches in diameter. At the outlet of the tidal pond on the north side of Compo Beach Road, the conduit under the dike would be 24 inches in diameter, the same as the present conduit in this area.

## E-6. LANDS AND DAMAGES

The estimated cost of furnishing necessary lands, easements, and rights-of-way, which would be one requirement of local cooperation, has been based on a field reconnaissance and the application of current market values as determined from a study of a number of recent sales in the general area. No land would be acquired in fee. Permanent easements would be acquired on about 4.5 acres and temporary easements on about 0.3 acres.

## E-7. RELOCATIONS

The construction of the plan would not require the relocation of any highways, railroads, or water lines. As part of the plan of protection, four highway intersections would be raised. It would be necessary to relocate several utility poles and one telephone booth which are within the construction area.

E-8. GEOLOGY OF SITE

The general geology of the Westport shoreline and foundation conditions for the protective structures are discussed in Appendix A.

E-9. AVAILABLE MATERIALS

Information on the availability of required construction materials is contained in Appendix A. It is anticipated that about fifty percent of the required topsoil would be available from excavation.

E-10. PLAN OF CONSTRUCTION

The plan of protection would require less than one year to construct and put into operation.

BASIS OF ESTIMATES OF FIRST COST AND ANNUAL CHARGES

E-11. COST ESTIMATES

The cost of construction has been estimated on the basis of a design which would provide economical and secure structures. Estimates of quantities have been made on the basis of the typical cross sections shown on Plate E-2. Earth borrow items include spoil, compaction in fill, and loss from borrow to fill.

E-12. UNIT PRICES

Unit prices are based on averages for similar types of projects either constructed, under construction, or under contract in New England and, where applicable, similar construction in other parts of the country. Adjustments have been made for the availability and location of materials and quantities required. The unit prices are on a 1960 price level.

E-13. CONTINGENCIES, ENGINEERING AND OVERHEAD

The estimate includes a 20 percent allowance to cover contingencies. The cost for engineering, design, supervision, and administration (see Table E-2) are estimated lump sums based on knowledge of the site and experience on similar projects.

E-14. LOCAL CONTRIBUTIONS

It is proposed that local interests contribute in cash toward the first cost of the project an amount presently estimated at $40,000, which is 30 percent of the first cost of the project less credit for furnishing lands, easements and rights-of-way and accomplishing necessary relocations of utilities. See Table E-3.

E-15. ANNUAL CHARGES

The estimate for annual charges is based on interest at 2.625 percent on the Federal investment in the project and 3.5 percent on the non-Federal investment and amortization over a period of 50 years. No allowance for the loss of taxes on lands is included in the annual charges since a large percentage of the lands are publicly owned. The loss of taxes from permanent easements of land now privately owned would be small. Cost of maintenance and operation of the project are based on a knowledge of the site and costs of similar projects. An allowance for major repairs, over and above normal maintenance, is included to cover the repairs that would be incurred by the overtopping of the dike by a tidal-flood level above the design stage of 10.5 feet msl - the record level experienced in 1938.

## FIRST COSTS AND ANNUAL CHARGES

E-16. FIRST COSTS

The first cost of the plan of protection for the Compo Beach area is estimated at $310,000 of which $217,000 would be borne by the United States and local interests would contribute in cash $40,000 and provide lands, easements, and rights-of-way, and accomplish all necessary relocations of utilities at an estimated cost of $53,000, a total local first cost of $93,000. Detailed breakdowns of the estimate, by principal features of the work, and by quantities and unit prices are shown in Table E-2.

E-17. ANNUAL CHARGES

The total annual charges for the plan of protection for the Compo Beach area amount to an estimated $15,300. Of this amount, $8,300 represents Federal annual charges and $7,000, non-Federal. The determination of the annual charges is shown in Table E-3.

TABLE E-2

ESTIMATED FIRST COSTS
(1960 Price Level)

HURRICANE PROTECTION PLAN FOR COMPO BEACH AREA

Westport, Connecticut

| Item | Estimated Quantity | Unit | Unit Price | Estimated Amount |
|---|---|---|---|---|
| **Dike and Appurtenant Works** | | | | |
| Preparation of site | 5 | Acres | L.S. | $ 1,000 |
| Earth exavation(common) | 12,000 | c.y. | 1.00 | 12,000 |
| Earth excavation(borrow) | 25,000 | c.y. | 1.20 | 30,000 |
| Earth fill | 23,000 | c.y. | .30 | 6,900 |
| Sand fill | 7,000 | c.y. | 2.00 | 14,000 |
| Gravel filter | 600 | c.y. | 3.00 | 1,800 |
| Bedding stone | 1,200 | c.y. | 7.00 | 8,400 |
| Cover stone | 6,000 | c.y. | 10.00 | 60,000 |
| Quarry stone | 250 | c.y. | 6.00 | 1,500 |
| Topsoil, seeded | 800 | c.y. | 5.00 | 4,000 |
| Pavement | 8,600 | s.y. | 2.00 | 17,200 |
| Modifications to drainage | 1 | Job | L.S. | 15,000 |
| Guard rail | 500 | l.f. | 2.00 | 1,000 |
| | | | Subtotal | $ 172,800 |
| Contingencies | | | | 34,200 |
| | | | | 207,000 |
| Engineering and design | | | | 31,000 |
| | | | | 238,000 |
| Supervision and administration | | | | 19,000 |
| Total Cost - Dike and Appurtenant Works | | | | $ 257,000 |

TABLE E-2 (Cont'd)

| Item | Estimated Quantity | Unit | Unit Price | Estimated Amount |
|---|---|---|---|---|
| **Relocation of Utilities** | | | | |
| Relocation of Utilities | 1 | Job | L.S. | $2,000 |
| Contingencies | | | | 400 |
| | | | | $2,400 |
| Engineering and design | | | | 350 |
| | | | | $2,750 |
| Supervision and administration | | | | 250 |
| Total Cost - Relocations | | | | $3,000 |
| **Lands and Damages** | | | | |
| Permanent easements | 4.5 | acre | L.S. | $29,500 |
| Temporary easements | 0.3 | acre | L.S. | 500 |
| Severance damage | 1 | job | L.S. | 7,500 |
| | | | | $37,500 |
| Contingencies | | | | 7,500 |
| | | | | $45,000 |
| Acquisition costs | | | | 5,000 |
| Total Costs - Lands and Damages | | | | $50,000 |
| **Summary** | | | | |
| Dike and Appurtenant Works | | | | $257,000 |
| Relocation of Utilities | | | | 3,000 |
| Lands and Damages | | | | 50,000 |
| Total First Cost | | | | $310,000 |
| Preauthorization studies | | | | 10,000 |
| Total Project Cost | | | | $320,000 |

TABLE E-3

ESTIMATED ANNUAL COSTS
(1960 Price Level)

HURRICANE PROTECTION PLAN FOR COMPO BEACH AREA

Westport, Connecticut

| | |
|---|---|
| **Federal Investment** | |
| First Cost | $217,000 (1) |
| Preauthorization studies | 10,000 |
| Total Federal Investment | $227,000 |
| **Federal Annual Costs** | |
| Interest on investment (2.625%) | $ 6,000 |
| Amortization (1.0%) | 2,300 |
| Total Federal Annual Costs | $ 8,300 |
| **Non-Federal Investment** | |
| Contributed funds | $ 40,000 |
| Relocation of utilities | 3,000 (3) |
| Lands, easements and rights-of-way | 50,000 |
| Total Non-Federal Investment | $ 93,000 (2) |
| **Non-Federal Annual Costs** | |
| Interest on investment (3.5%) | $ 3,300 |
| Amortization (0.763%) | 700 |
| Maintenance and operation | 3,000 |
| Total Non-Federal Annual Costs | $ 7,000 |
| TOTAL ANNUAL COSTS | $ 15,300 |

(1) 70% of $310,000 first cost
(2) 30% of $310,000 first cost
(3) Includes allowance for major repairs

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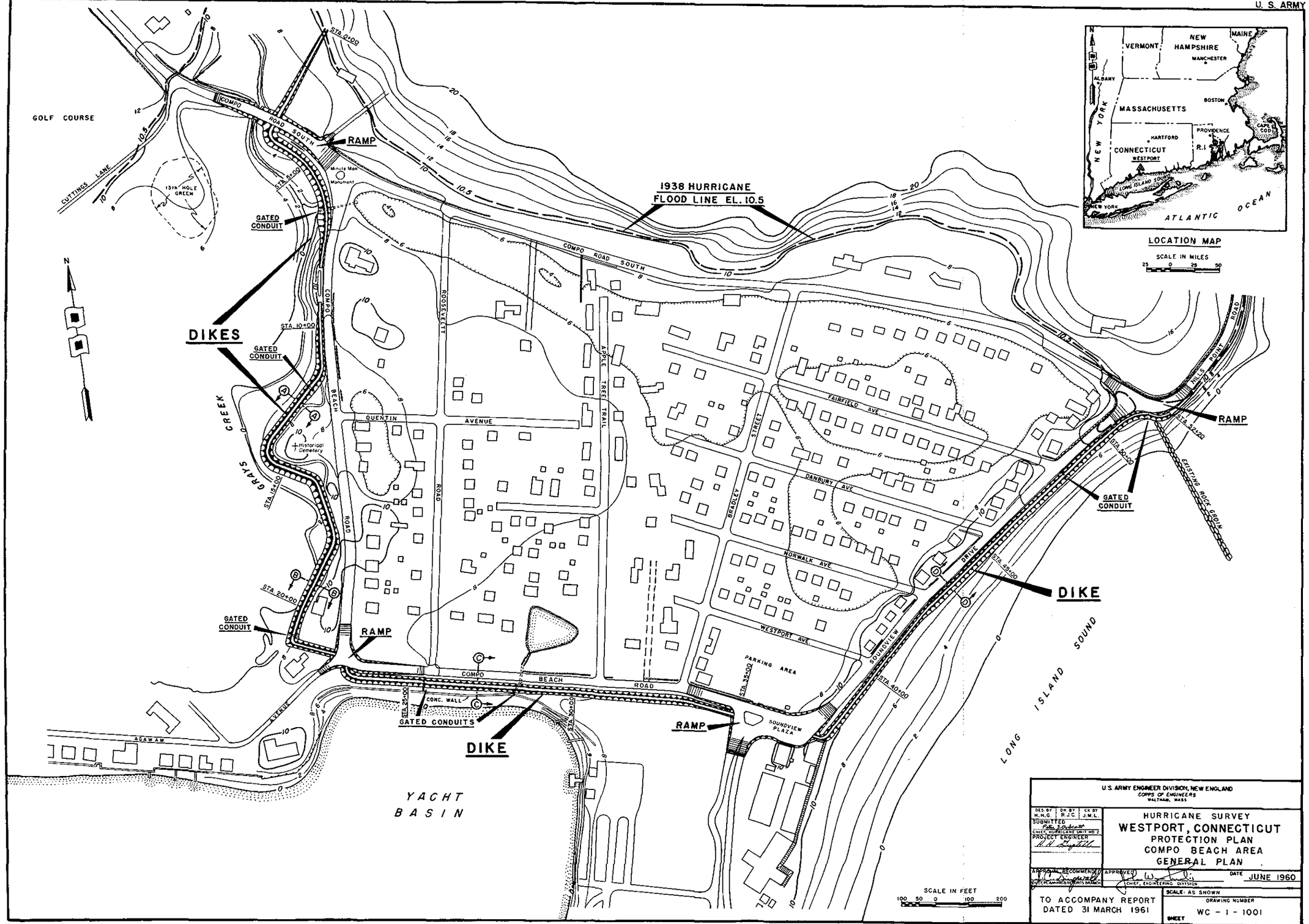



U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

| DES. BY | DR. BY | CK. BY |
|---|---|---|
| M.M.G. | R.J.C. | J.M.L. |

SUBMITTED
CHIEF, HURRICANE UNIT NO. 2
PROJECT ENGINEER

APPROVAL RECOMMENDED
CHIEF, PLANNING BRANCH

APPROVED
CHIEF, ENGINEERING DIVISION

DATE JUNE 1960

# HURRICANE SURVEY
# WESTPORT, CONNECTICUT
## PROTECTION PLAN
## COMPO BEACH AREA
## GENERAL PLAN

TO ACCOMPANY REPORT
DATED 31 MARCH 1961

SCALE: AS SHOWN

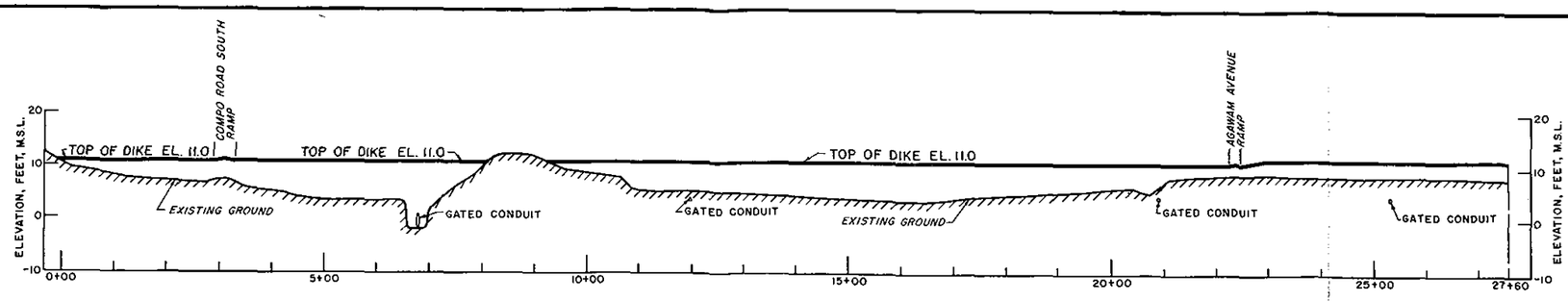
DRAWING NUMBER
WC - 1 - 1001

SHEET

PLATE E-1

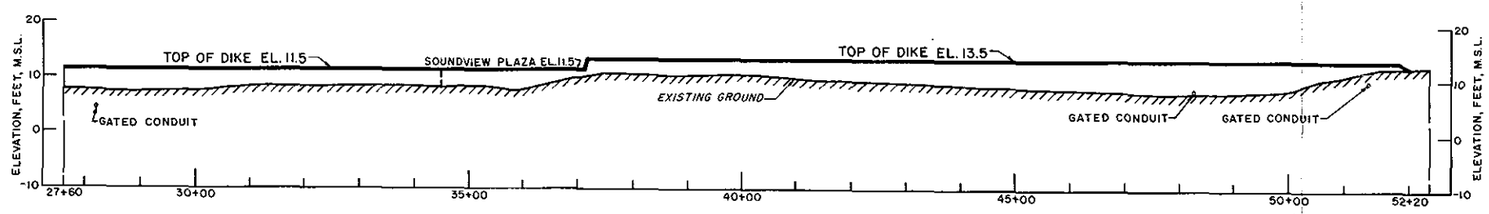
CORPS OF ENGINEERS

U. S. ARMY



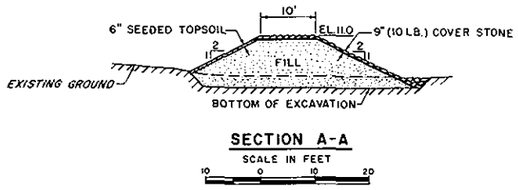

PROFILE ALONG ℄ OF DIKE

SCALE: AS SHOWN




PROFILE ALONG ℄ OF DIKE

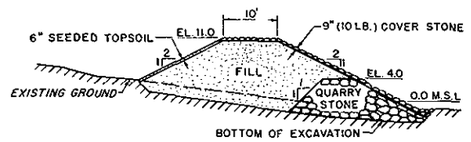
SCALE: AS SHOWN




SECTION A-A

SCALE IN FEET

10 0 10 20




SECTION B-B

SCALE IN FEET

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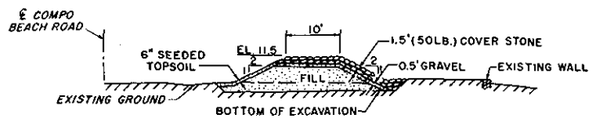
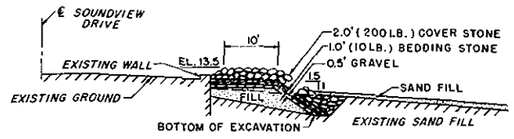



SECTION C-C

SCALE IN FEET

10 0 10 20




SECTION D-D

SCALE IN FEET

10 0 10 20

NOTE:

*Elevations are in feet and are referred to the plane of Mean Sea Level.*

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

| DES. BY H.H.G. | DR. BY R.J.C. | CK. BY J.M.L. |
|---|---|---|

SUBMITTED
CHIEF, HURRICANE UNIT NO. 2

PROJECT ENGINEER

APPROVAL RECOMMENDED
CHIEF, PLANNING AND REPORTS BRANCH

APPROVED
CHIEF, ENGINEERING DIVISION

DATE JUNE 1960

HURRICANE SURVEY
WESTPORT, CONNECTICUT
PROTECTION PLAN
COMPO BEACH AREA
PROFILE & SECTIONS

TO ACCOMPANY REPORT
DATED 31 MARCH 1961

SCALE AS SHOWN

DRAWING NUMBER
WC-1-1002

SHEET

PLATE E-2

# APPENDIX F

## LETTERS OF COMMENT

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE

PUBLIC HEALTH SERVICE

REGION 11
42 BROADWAY
NEW YORK 4, N. Y.

Refer to: 24: SE

September 8, 1960

Colonel Karl F. Eklund
Deputy Division Engineer
Corps of Engineers
U. S. Army Engineer Division,
New England
424 Trapelo Road
Waltham 54, Massachusetts

Dear Colonel Eklund:

Reference is made to your letter of May 24, 1960 relative to the proposed plan for providing protection against hurricane tidal-flooding in the town of Westport, Connecticut.

We have consulted with the Connecticut State Water Resources Commission. The review indicates that the preliminary plan for the Compo Beach area should have no effect upon the pollution of the waters in this area.

For the Regional Engineer.

Sincerely yours,

L. M. Klashman

Lester M. Klashman
Regional Program Director
Water Supply & Pollution Control

STATE OF CONNECTICUT
WATER RESOURCES COMMISSION
STATE OFFICE BUILDING · HARTFORD 15, CONNECTICUT

August 26, 1960

Colonel Karl F. Eklund
Deputy Division Engineer
Corps of Engineers, U. S. Army
424 Trapelo Road
Waltham 54, Massachusetts

Dear Colonel Eklund:

Through an oversight, your letter of May 24, 1960 concerning the hurricane protection project for Westport was not answered. I regret the long delay.

We have reviewed the preliminary plan for the proposed hurricane-tidal flood protection project for the Compo Beach area. This review indicates that the construction of the proposed project should have no effect upon pollution of the waters in the area.

Very truly yours,

William S. Wise

William S. Wise
Director

ADDRESS ONLY THE
REGIONAL DIRECTOR

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
59 TEMPLE PLACE
BOSTON, MASSACHUSETTS

NORTHEAST REGION
(REGION 5)
MAINE
NEW HAMPSHIRE
NEW YORK
VERMONT
PENNSYLVANIA
MASSACHUSETTS
NEW JERSEY
RHODE ISLAND
DELAWARE
CONNECTICUT
WEST VIRGINIA

June 1, 1960

The Division Engineer
New England Division
U. S. Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

The Bureau of Sport Fisheries and Wildlife in cooperation with the Connecticut State Board of Fisheries and Game has studied the fish and wildlife aspects of proposed dikes for the protection of the Compo Beach area of Westport, Connecticut, against hurricane tidal floods.

The construction of onshore dikes around Compo Beach as shown in the map attached to your letter of May 24 would have no significant adverse effects on the fish and wildlife resources of the area. No detailed study by this Bureau is contemplated.

Please inform us of any departures from the present construction proposals which may occur at later planning stages.

Sincerely yours,

E. W. Bailey
Acting Regional Director

STATE OF CONNECTICUT
*BOARD OF FISHERIES AND GAME*
2 WETHERSFIELD AVENUE • HARTFORD, CONNECTICUT

ADDRESS ALL MAIL TO
STATE OFFICE BUILDING, HARTFORD

June 29, 1960

Mr. John Wm. Leslie
Chief, Engineering Division
Corps of Engineers
424 Trapelo Road
Waltham 54, Mass.

Dear Mr. Leslie: RE: NEDGW

Reference is made to the proposed hurricane protection project for the Compo Beach area in Westport, Conn.

After studying the proposed plan we feel there will be no significant adverse effect on fish and wildlife resources as a result of the project.

We request to be informed of any alterations of the original plans for the project.

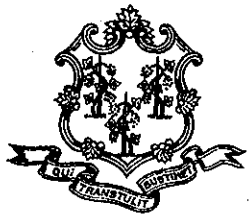
Very truly yours,

O E Beckley

O. E. Beckley, Supervisor
Game Management

OEB:N
CC: Schueler
Wise
Schmidt
Nelson
Fish Div.
Col.Eklund
Marston

ABRAHAM RIBICOFF
GOVERNOR




STATE OF CONNECTICUT
EXECUTIVE CHAMBERS
HARTFORD

September 19, 1960

Brigadier General Alden K. Sibley
Division Engineer
U. S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear General Sibley:

Thank you for your report on the Westport hurricane survey.

I have been informed by Director William Wise of the Connecticut Water Resources Commission that First Selectman Baldwin of Westport has assured him that Westport desires the proposed protection plan and will provide the necessary local contributions.

On that basis, with the Town of Westport meeting the conditions of cooperation which you recommend, the State of Connecticut is glad to favor the project.

Sincerely,

Abraham Ribicoff

Governor

R:mh

*Herbert E. Baldwin*
FIRST SELECTMAN

*Elliott J. Roberts*

*Albert T. Scully*

all ⋆ America city—1958

# WESTPORT

connecticut

August 11, 1960

General Alden K. Sibley, Division Engineers
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear General Sibley:

Reference is made to the Compo tidal flooding project under study by the U. S. Army Engineer Corps. This letter is in response to your letter of June 10, and a letter dated May 10 of Mr. John Wm. Leslie, Chief, Engineering Division, and in confirmation of recent phone conversation with Mr. Scott.

After testing out the sentiment of the property owners in the Compo Beach area by questionnaire from the local Flood and Erosion Control Board, it is concluded by the Flood and Erosion Board that there is evidence of sufficient interest to warrant local support of the protection plan as revised by the Corps of Engineers.

It is my feeling as First Selectman, at this time, that Westport would favor the revised protection proposal and that the Town, thru benefit assessment to property protected, would share in the cost of the project.

It is hoped that the proposal will continue to have the consideration of the Army Engineer Corps.

Yours truly,

Herbert E. Baldwin
First Selectman

HEB:MC

*Herbert E. Baldwin*
FIRST SELECTMAN

*Elliott J. Roberts*

*Albert T. Scully*

all ⋆ America city—1958

**WESTPORT**

connecticut

June 8, 1961

Seymour A. Potter, Jr.
Brigadier General, USA
U. S. Army Engineer Division, New England
424 Trapelo Road
Waltham 54, Massachusetts

Dear General Potter:

I have been advised that a favorable recommendation of a hurricane protection project for the Compo Beach area of Westport will include a requirement that town officials periodically notify those affected that the dike protection provided by the project is limited to a tidal-flood level of 10.5 feet above mean sea level, the record level of flooding experienced in the hurricane of September 1938. The Selectmen of Westport will be pleased to comply with such a requirement.

The Town of Westport has a regularly scheduled program and plan for the evacuation of flooded areas in times of an emergency. The program incorporates the services of personnel and equipment of our local police and fire departments, other departments and agencies of the town, and civilian defense. The program includes provisions for the sheltering and care of evacuated residents.

The desire of the local interests in Westport has been for protection limited to the 1938 flood level. We believe that protection of this degree will greatly reduce the tidal-flood nuisance in the Compo Beach area and will constitute a desirable project. We are pleased that it is

receiving your recommendation. Realizing, however, that the protection could be overtopped in the event of a future hurricane causing flooding higher than that experienced in 1938, our present plans for the evacuation of low-lying flooded areas at the times of a hurricane or other severe storm will continue to include provisions for the evacuation of the Compo Beach area when and if such steps appear to be necessary. When partial protection is afforded to the Compo Beach area by the construction of dikes, other danger areas in the town can be given a higher priority in the evacuation schedule.

Yours very truly,

Herbert E. Baldwin
First Selectman

HEB:MC